The
Practical Engineer

A monthly journal, devoted to the economical generation and utilization of power and to the interests of stationary engineers

VOL. X. PHILADELPHIA, SEPTEMBER, 1906. No. 8.

OFFICE ELECTRIC DEPT.

SOME PRINCIPLES OF HEAT

Heat Engines, Saturated and Superheated Steam, Methods for Finding Moisture in Steam

When heat energy disappears as heat it must, according to the principle of the conservation of energy, appear or exist in some other form of energy. When the heat in the steam drives the piston of an engine, the steam loses heat by the operation and an exact equivalent of the energy so disappearing reappears as work done or as energy of the moving parts of the engine, except that which is taken up by radiation and friction. The mechanical equivalent of a heat unit is called "Joule's equivalent," because it was he who made the first determination of the mechanical equivalent of a heat unit, in Manchester, England. After a series of experiments extending over seven years, and while he at that time came to the conclusion that its value was 772 foot pounds, yet later experiments have proved it to be too small, so that Joule's equivalent is now universally taken as 778 foot pounds.

The first law of thermodynamics, which is the science of heat, can now be stated: Heat and mechanical energy are mutually convertible in the ratio of about 778 foot pounds for the British Thermal Unit.

Heat Engines.—In general, heat engines are machines for continuously transforming heat into work. Such engines in practice work in cycles. One of the best-known principles on which an imaginary heat engine works was devised by Carnot and it involves the most important fundamental principle of this science and is known as "Carnot's cycle."

In any heat engine it is essential that there should be: 1st, a working fluid; 2d, a source of heat, and 3d, a receptacle for unexpended heat, both of which latter must be external to the working fluid. In the operation of a heat engine, it must receive the heat of the working fluid at a certain temperature, it must convert the heat into work and it must discharge the unconverted heat at a lower temperature than that at which it was received. The difference between such higher and lower temperature is called the "range of temperature" and the engine is called a perfect engine when the whole heat corresponding to its range of temperature is converted into work. The ratio of the maximum mechanical effect in a perfect heat engine to the total heat expanded on it is a function solely dependent upon the initial and final temperatures at which heat is received and rejected, and is independent of the nature of the working fluid.

Based upon the experiments made by Joule, Rankine and others, the following laws have been established:

1st. In any heat engine the maximum useful effort, expressed in foot pounds or in percentage, bears the same relation to the total heat expended that the range of temperature bears to the absolute temperature at which heat is received.

2d. In any heat engine, the minimum loss of heat bears the same relation to the total heat expended as the temperature at which the heat is rejected bears to the temperature at which it is received; both being reckoned from absolute zero.

Absolute Zero.—The absolute zero of temperature upon which all calculations for the efficiency of heat engines are based, corresponds to the condition of the total deprivation of heat. This temperature has never been reached, the nearest approach to it being produced by the expansion in liquefying air, oxygen and hydrogen. It has been determined by computation that 460 degrees below the zero on the Fahrenheit scale is the point of absolute zero.

The above laws expressed in algebraic form are as follows:

$$E = \frac{t_1 - t_2}{t_1}$$

where E is the efficiency and t_1 and t_2 the initial and final temperatures, respectively, and based upon the absolute zero of temperature. The only theoretical way, then, of increasing the efficiency of an elementary engine is to increase the range of temperatures between which it is worked.

This, therefore, shows that the latent heat which is common to steam is not necessarily wasted. It is often generally supposed that if all the heat received by the steam was expended in elevating its temperature, instead of going into a latent condition, a larger percentage could be turned into power. It has been upon this supposition that the use of most of the substitutes for steam has been based. To show that this supposition is not true, it is only necessary to consider the engine using steam as a gas without expenditure of latent heat and compare it with results attained in engines in which latent heat is expended in the boiler and discharged in the condenser. Assume, for instance, that steam be supplied at 320 degrees temperature and exhausted from the engine at 28 inches vacuum or 100 degrees, then according to the above formula,

the heat efficiency of the engine will be

$$E = \frac{780 - 560}{780} = 28 \text{ per cent.}$$

The heat expended per pound of steam would be $220 \times .475 \times 778 = 81{,}301$ foot pounds, of which the engine would utilize 28 per cent., or 22,764 foot pounds. Since one horse power is equivalent to 1,980,000 foot pounds per hour, there would, therefore, be required $1{,}980{,}000 \div 22{,}764 = 86.9$ pounds of steam per horse power per hour and that in a perfect engine; but within the same limits in an ordinary steam engine, using water with its large latent heat, a horse power is often obtained on from 16 to 18 pounds of steam.

As the lowest available temperature and highest practical pressure are the same for all vapors, it becomes evident that fluid having the highest temperature at the limit of pressure, has the advantage, theoretically, in possible economy. Of all available liquids, water fulfills this condition best and its great abundance and low cost more than counterbalance any other advantages which other liquids might have.

Generating Steam.—The chemical composition of water consists of two parts hydrogen and one part oxygen and exists in three states or conditions: ice, water and steam; the only difference between these states or conditions is the presence or absence of a quantity of energy which may be either indicated on the thermometer or be in the form of latent heat. If we have a pound of ice say at zero degrees, by adding heat to it, it will grow warmer until a temperature of 32 degrees is attained. At this point heat can be added until all the ice is melted without any difference of the temperature. After all the ice is melted, the addition of more heat will cause the temperature to again rise, but more slowly than before, because it takes about twice as much heat to raise a pound of water one degree that it does a pound of ice. The addition of more heat will cause the temperature to rise until another critical point is reached and that is when the water starts to boil. If the water is under atmospheric pressure, it will boil at 212 degrees and it will be found that a large quantity of heat will be required before all the water is turned into steam without raising the temperature above 212 degrees. The amount of heat which one pound of water will require in being raised from water at 212 degrees into steam at 212 degrees, is equal to 966 heat units or enough heat to have raised the water to a temperature of 1,178 degrees if the specific heat of the water had remained constant. Thus over four-fifths of the heat which has been added to the water has disappeared or become insensiblbe to the thermometer.

After steam has been formed, a further addition of heat increases the temperature again at a much faster ratio to the quantity of heat added, according to whether the steam is kept at a constant pressure or a constant volume. This can be continued until such a point is reached that the steam will disassociate into its original gases of hydrogen and oxygen.

In changing ice from zero to 32 degrees, $32 \times .504 = 16.1$ heat units are required. In changing ice at 32 degrees to water at 32 degrees, 144 heat units are required. In changing water from 32 to water at 212 degrees, $212 - 32 = 180$ heat units are required. In changing water from 212 degrees to steam at 212 degrees, 966 heat units are required and in changing steam to a temperature above 212 degrees, 0.48 heat units are required for each degree the temperature is raised.

The above data applies only when the water is at atmospheric pressure. At any other pressure, not only are the melting point and boiling points changed, but the latent heat of vaporization is also changed. The temperature of boiling and latent heat for different pressures has been found carefully by experiment and can be found in any steam tables.

As a result of experiments, the total heat above 32 degrees of steam for any temperature can be found from the formula

$$H = 1019.7 + .305(t - 32°)$$

in which t is the temperature of boiling and H, the number of heat units above 32 degrees.

Latent Heat of Steam.—The formula for the latent heat of steam has also been found by experimentation and is given as follows:

$$L = 1091.7 - .695(t - 32°)$$

in which t is the temperature of boiling and L, the latent heat of vaporization.

Saturated and Superheated Steam.—Saturated steam is steam whose temperature is due to its pressure and is the kind of steam always given off from a body of boiling water. It may be either wet or dry, depending upon whether it contains particles of water suspended in it or not. Superheated steam is steam which is heated to a temperature above that due to its pressure. In order to superheat steam, it must be done outside of the presence of the water from which it was generated.

Quality of Steam.—In general practice, the steam given off by a steam boiler contains more or less moisture. If it contains no moisture, it is said to be dry and the quality is 100 per cent., but if it is wet, the amount of water in the steam is expressed by the quality of the steam. Thus steam of a quality of 98.5 per cent. contains 1.5 per cent. moisture. The amount of moisture in the steam as given off by the boiler depends upon the design, the kind of feed water used and the degree to which the boiler is forced.

Calorimeters.—The apparatus used to determine the amount of water in the steam is called a calorimeter. In its earlier forms, a barrel filled with the water was used, but at the present time, modern calorimeters of the throttling or separator type are used.

When making boiler or engine tests, for the purpose of finding the efficiency and economy of the engine or boiler, it is very important that the amount of water in the steam be known, because in the case of a boiler, if the amount of water in the steam were not known, the efficiency of the boiler would appear higher than it actually would be, because if a certain percentage of the feed water is not evaporated, the boiler does not give up the whole amount of heat which indicated by the number of pounds of feed water evaporated, the temperature of the feed and the pressure of the steam. In the case of a steam engine, it is not fair to credit the engine with a certain steam consumption unless it is known that all the steam flowing into the engine is dry steam. Consequently it is of importance to know the general methods in use for finding the moisture in the steam.

Barrel Calorimeter.—The barrel calorimeter consists of a wooden barrel placed upon a platform scale, as shown in Fig. 1. The scales should weigh accurately to the quarter pound. Into this barrel is led a pipe, either of iron or a piece of rubber hose, from the main containing the steam to be heated. The barrel should contain about 300 pounds of

water and when careful measurements are required, it should be covered with a lagging of good non-conducting material to prevent radiation.

In making the test for the quality of the steam, the weight of the water in the barrel should be closely determined and its temperature taken, for which purpose an accurate Fahrenheit thermometer should be used. Now blow steam through the pipe into the air until all condensation is blown out of the pipe and the pipe thoroughly heated. Then turn the current of steam into the water in the barrel, keeping the end of the pipe near the bottom of the barrel so that all the steam will be condensed. While the steam is being condensed, the water should be thoroughly stirred with a wooden paddle, so as to

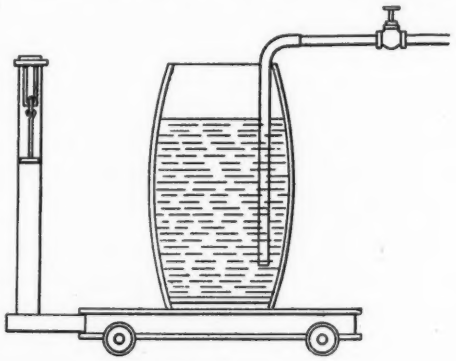


Fig. 1.

obtain a uniform temperature throughout the water. When the temperature has risen to about 110 degrees, the flow of steam should be stopped and the steam pipe removed. At the same time the temperature of the water and its weight should be found. The necessary data is now obtained for making the calculation of the quality of the steam. The steam that enters is composed partly of dry steam and partly of water, the percentage of which can be found from the formula.

$$Q = \frac{W(t_2 - t_1)}{wl} - \frac{t_1 - t_2}{l}$$

in which Q is the quality of the steam, W is the weight of cold water in the barrel at first; w is the difference between the first and last weight of water in the barrel; t_2 is the final temperature of the water in the barrel; t_1 is the original temperature of the water; t is the temperature of the steam being tested and can be obtained from the steam table if the pressure is known; l is the latent heat of the steam at the pressure in the steam pipe, which also can be found in the steam table. The quantity Q will give the quality of the steam in per cent.

Throttling Calorimeters.—Fig. 2 shows a section through a typical form of instrument. Steam is drawn from the vertical pipe by a nipple. It should be made of ½-inch pipe and should extend across the diameter of the steam pipe to within half an inch of the other side, being closed at the end and perforated with not less than twenty ½-inch holes equally distributed along and around its cylindrical surface, but none of these holes should be nearer than ½ inch to the inner side of the steam pipe. The calorimeter and the pipe leading to it should be well covered with felting. These precautions should be taken with all forms of calorimeters so that a proper sample of the steam be obtained.

Having connected the calorimeter to the sampling pipe, a hole about ⅛-inch diameter in the disc, as shown. It next passes around the lower thermometer cup, after which it is permitted to escape. Thermometers are inserted into the cups, which are filled with cylinder oil and when the whole apparatus is heated, the temperature of the steam before and after passing through the hole in the disc is noted.

The calculations are based upon the fact that when steam passes from a higher to a lower temperature, as in this case, no work is done in overcoming resistance and assuming that there is no loss from radiation, the quantity of heat is exactly the same after passing the disc as it was before. Suppose that the higher steam pressure is 150 pounds by gauge and the lower pressure that of the atmosphere. The total heat in a pound of dry steam at the former pressure is 1193.5 British Thermal Units, and at the latter pressure 1146.6 British Thermal Units, difference 46.9 British Thermal Units. As this heat still exists in the steam of lower pressure, its effect is to superheat that steam. Assuming the steam to have been dry originally and knowing that the specific heat of steam is 0.48, the steam will then be superheated $46.9 \div 0.48 = 97.7$ degrees. Suppose, however, the steam had contained one per cent. of moisture. Before any superheating could occur, this moisture would have to be evaporated into steam at atmospheric pressure. Since the latent heat of steam at atmospheric pressure is 965.8 British Thermal Units, it follows that one per cent. of moisture would require 9.65 British Thermal Units to evaporate it, leaving only $46.9 - 9.65 = 37.25$ British Thermal Units available for superheating, hence the superheat would be $37.25 \div 0.48 = 77.6$ degrees as against 97.7 degrees if the steam were dry.

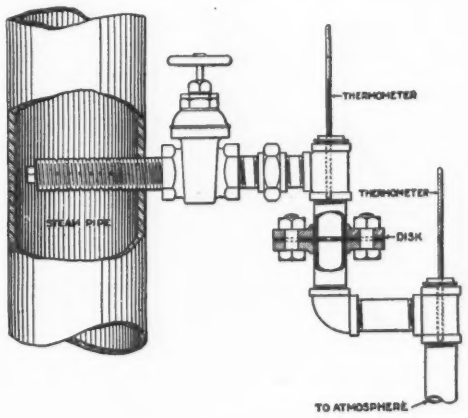


Fig. 2.

Based upon these principles, any amount of moisture in the steam can be found.

Let H = total heat of steam at boiler pressure,
L = latent heat of steam at boiler pressure,
h = total heat of steam at reduced pressure after passing disc,
t_1 = temperature of saturated steam at reduced pressure,
t_2 = temperature of steam after expanding through disc,
0.48 = specific heat of saturated steam,
X = proportion of moisture in steam.

The difference between the heat units in a pound of steam at boiler pressure and after passing the disc, is the heat which

steam is led around the upper thermometer cup, then through must evaporate the water in the steam and do the superheating, hence

$$H - h = XL - 0.48(t_2 - t_1)$$

or

$$X = \frac{H - h - 0.48(t_2 - t_1)}{L}$$

In most all throttling calorimeters, the lower pressure is taken as that of the atmosphere, in which case $h = 1146.6$ and $t_1 = 212$, hence the formula becomes

$$X = \frac{H - 1146.6 - 0.48(t_1 - 212)}{L}$$

In practical work, the upper thermometer may be dispensed with and an accurate steam gauge may be used.

Napier's Law of the Flow of Steam into the Atmosphere.—When steam flows through an orifice into the atmosphere, such as the hole in disc, Figs. 2 and 3, the amount of steam flowing through is proportioned to the pressure of the steam and the area of opening. Napier's approximate formula is as follows:

$$\text{Pounds of steam per second} = \frac{p\ a}{70}$$

in which p = absolute pressure in pounds per square inch and a = area of orifice in square inches.

Separating Calorimeter.—The separating calorimeter mechanically separates the entrained water from the steam and collects it in a reservoir, as shown in Figs. 3 and 4. The steam flows out of the calorimeter through an orifice of known size, so that either its total amount can be calculated by the Napier's formula or it can be condensed and weighed. Fig. 3 shows one form of separator calorimeter that can be easily made. It consists of a main chamber B, to which is attached a water gauge A. Above this chamber B are several other pipe connections. One of these, F, admits the steam which is to be tested for moisture. It opens into E, which is continued downward into chamber B, as shown by the dotted lines. This pipe is perforated with a large number of holes about ⅛ inch in diameter. The steam, entering at F, is deflected into pipe E and escapes into chamber B through the small holes, in doing which the moisture is removed, and falls to the bottom of chamber B. It is on this account that the name separating calorimeter has been applied to this instrument, since it acts upon the principle of the ordinary and familiar steam separator. The steam, freed thus of its moisture, passes up and out of the pipe C. In this pipe is placed a diaphragm D, in which is drilled a hole $^1/_{16}$ inch in diameter. At G is a pipe opening into the space connecting F and E, to which a steam gauge may be attached.

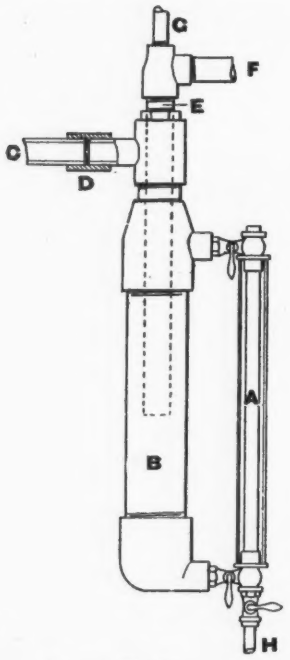


Fig. 3.

The operation of this style of calorimeter is as follows: The steam to be tested is admitted through the pipe F. As it escapes from pipe C, it should be led into a tank of cold water and condensed. In beginning a test, first blow steam through the calorimeter to heat it. Then turn the escaping steam into the condensing tank and note the level of the water in the gauge glass A. This water level should be kept constant during the test, which can be done by drawing it off as fast as it collects through the cock A, this moisture being kept and carefully weighed at the end of the test. When the steam has run for about half an hour, the test is stopped by shutting off the steam, drawing off the water in the gauge to its original level, and weighing the steam condensed in the tank. Then knowing the weight of steam W discharged from C and condensed: w, the weight of moisture drawn from chamber B; and the loss R due to radiation from the surface of the calorimeter; we have for the quality of the steam

$$Q = \frac{W + R}{W + w}$$

The radiation loss R is found by coupling another separator calorimeter, just like the one shown, to the pipe C. The steam leaving the first calorimeter and entering the second is dry steam, so that any moisture which collects in the latter, called R in our formula, is due to the condensing effect of the second instrument. And since the two are alike, it may be taken as the radiation loss of the first also.

It may be that in some cases it would be very inconvenient to condense the escaping steam. In such a case the amount of steam escaping may be calculated by taking the exact time during which steam flows, as well as the steam pressure by gauge at G, according to Napier's formula.

Fig. 4 shows a Carpenter separator calorimeter in which the readings can be read off directly on the gauges A and B. Gauge A shows the number of ounces of water collected from the moisture in the steam and gauge B indicates not only the steam pressure but the amount of steam flowing through orifice *O* in 10 minutes. The steam flows through the steam pipe as shown and is made to change its direction in going through the calorimeter, the moisture being thrown down in the interior chamber D while the dry steam flows through the outside chamber E and out through orifice O. The method of procedure is as follows: After the calorimeter is connected, it should be carefully insulated and warmed up by allowing steam to flow through it. When the test is started, the gauge hand A should be set to the level of water in D which is indicated on gauge glass G. Steam should be allowed to flow for 10 minutes when the level of water in D should again be

found, the difference in the level being the amount of moisture in the steam passing through the calorimeter. The amount of dry steam passing through O is indicated on gauge B, which has been calibrated for all pressures. If then W represents the weight of dry steam and *w* represents the weight of the moisture, then the quality Q can be found from the formula

$$Q = \frac{W + w}{W}$$

Superheated Steam.—Superheated steam is steam whose temperature exceeds that of saturated steam of the same pressure. It is produced by adding additional heat to saturated steam which has been removed from contact with the water from which it was formed. Its properties approximate

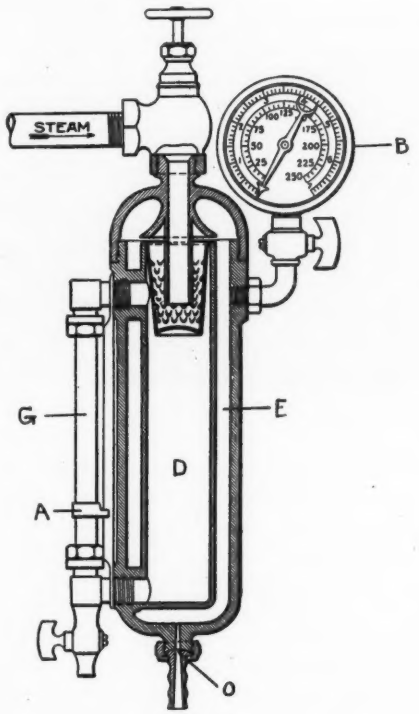


Fig. 4.

those of a perfect gas and it does not conduct heat as well as saturated steam.

There are several reasons why superheated steam is used in engineering. It is used because there is always a loss of heat from radiation in steam pipes, and the heat so lost represents an equivalent condensation when the pipe conveys saturated steam. Superheated steam cannot condense; it must first lose all its superheat and be reduced to saturated steam. In consequence, if sufficiently superheated, it can lose the amount of heat represented by radiation from the steam pipes and at the same time reach the engine perfectly dry.

In the steam turbine, it is used because the energy in the steam is transformed into velocity, in which case, should there be any moisture in the steam, it will have a tendency to corrode and wear away the turbine blades which would cut down its efficiency very much. In an engine steam is admitted to the cylinder after it has been cooled by the exhaust each stroke. The heat necessary to bring the temperature from that of the exhaust to that of the entering steam must be supplied by the entering steam with the result that when saturated steam is used, some of it must inevitably condense. This amount of condensation may run as high as 20 to 30 per cent. of the weight of the steam used. If, however, an amount of heat could be brought with the steam sufficient to warm the cylinder walls, without condensing the steam, an amount of steam very much less could be used. This can be done by superheating.

Fuel Needed for Superheating.—The superheating of saturated steam naturally requires heat. Based upon the fact that for every pound of saturated steam that is raised one degree, 0.48 British Thermal Units is required, it may be calculated that the fuel used to generate saturated steam must be increased by about the following percentages in order to superheat the steam to the degrees named:

Degree of Superheat.	Additional Fuel Needed.
75°	5 per cent.
100°	7 "
150°	11 "
200°	15 "
250°	20 "

In engineering practice, it has not yet been definitely determined whether economy is effected by the use of superheat. It depends to a large extent upon the design of the engine. In a reciprocating engine, the superheat which may be used to advantage is limited by the design of the working parts, and any considerable amount of superheat increases the difficulty of lubrication and causes trouble with the packings. With the steam turbine, the use of high superheat is not so limited, but the blades have a tendency to warp, due to the high temperature.

Advantages of Multi-Staged Air Compression.

The chief advantages of multi-stage over single-stage compression of air are as follows:

1. Lower average temperature, resulting in lower average pressure and permitting the compression of the same volume of air with less expenditure of energy, as explained above.

2. Increased safety and ease of lubrication. When high final temperatures prevail, part of the lubricating oil vaporizes and wear on the piston and cylinder becomes rapid. Under exceptional circumstances the combination of air and oil vapor may reach the proportions of an explosive mixture and, if the compression temperature passes its flash point, damage may result. Such accidents are, however, very rare even in single-stage work; in multi-stage compression, with proper inter-cooling, they are impossible.

3. Greater effective capacity in free air. The final pressure in the low-pressure cylinder is much lower than in a single-stage machine, and the air confined in the clearance spaces when expanded down to atmospheric pressure occupies comparatively little space. Consequently the inflow of air through the suction valves begins at an earlier point in the stroke.

4. The air delivered by a two-stage or multi-stage compressor is dryer than that furnished by a single cylinder. Under constant pressure the power of air to hold water vapor decreases with its temperature, and during its passage through the inter-cooler much of the original moisture in the air is precipitated. Consequently less trouble is experienced from condensation in the discharge pipe.

THE ECONOMIC DISTRIBUTION OF STEAM

The Use of an Engine Model Greatly Facilitates the Proper Understanding of the Subject

By Henry M. Statz.

To the student of steam engineering, there is not a more interesting nor a more perplexing study than the economic distribution of steam in the cylinder of a steam engine. The steam is admitted to the cylinder to perform useful work and is released therefrom, the whole operation being performed by one valve, two valves or four valves. No matter what number of valves are used to perform the functions of admission, cut-off, expansion, release, exhaust closure and compression, the same terms are employed to designate the different phases which the steam pressure assumes during each stroke of the piston and certain principles assert themselves upon investigating the subject.

The study may be pursued through books with illustrations, diagrams and explanations of valve movements or by making different adjustments to the valve gear of any steam engine whereby a more or less thorough understanding may be acquired, but the most thorough and exhaustive study and understanding are attained by the use of a working model of the steam engine on a small scale.

Fig. 2. Fig. 3.

On determining that the use of the model was the most convenient method to study valve movement, the distribution of steam in the cylinder and the correct design and setting of valves, I therefore set about making one which would serve the purpose and elucidate the above problem. With the aid of this model, I have mastered what was once to me the bugbear and stumbling-block to the progress of the study of steam engineering, more especially steam engine design.

By referring to Fig. 1, which is a photograph of the model,

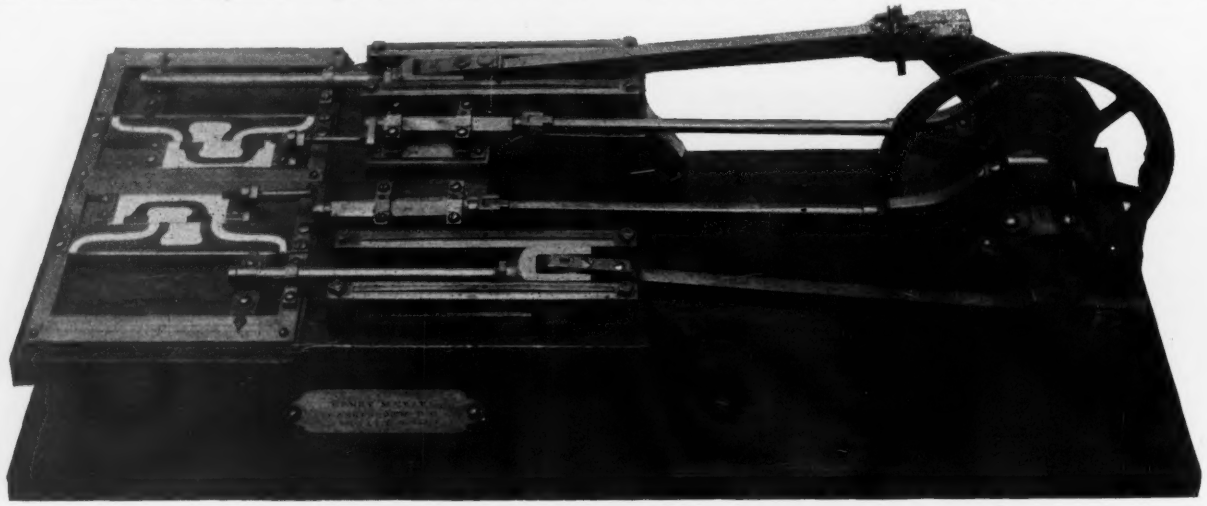


Fig. 1

it will be seen that the valves, ports and bridges may be drawn to scale on strips of paper and secured to their proper positions by means of clips. A common D-slide valve, a double-ported valve, a piston valve, a riding cut-off or a gridiron valve may be drawn and their movements with reference to the piston travel may be noted.

Owing to the inability or difficulty of measuring the exact position of the piston in the cylinder of a steam engine at any part of the stroke with reference to the position of the valve and the difficulty of obtaining the amount of lap or other conditions of measurement, such as the exhaust cavity of a valve, it becomes well-nigh impossible for the student to fully understand the subject. With the model, the student can readily determine the proper design of the valve; he can see at a glance the need of lead, the effects of lap to secure expansion, the value of exhaust lap which regulates compression and the effect of changing the angular advance.

The angularity of the connecting rod will point the way why the valve cannot be set to operate exactly the same at both ends of the cylinder, why the events of the stroke cannot be independently adjusted, why adjusting one event will distort another and so on. It will be understood that different kinds of valves require a different length of travel; for instance, a gridiron valve will require less travel than a plain slide valve; therefore, to make the model adaptable to the several kinds, I made adjustable throw eccentrics which are very simple and by means of which the eccentric can be regulated or adjusted to produce the necessary variations of from ⅛ of an inch to ½ of an inch to suit conditions. The accompanying illustration, Fig. 2, shows the eccentric at its

greatest throw and Fig. 3 shows another at its least throw or eccentricity. The construction of these eccentrics is so simple and withal so well adapted to the wide range of adjustments necessary to the length of travel of the different kinds of valves that they are an absolute necessity to the proper and complete construction of a serviceable model.

By close examination of the illustrations of the eccentrics, a drawing of same would be unnecessary in order to make similar ones. Any engineer or student of engineering who makes one of these models in his spare time will be amply repaid for his labor by what he will learn in consequence both in acquiring skill as a mechanic and in technical knowledge as an engineer. The principal dimensions of my model are: stroke, 3 inches; width of cylinder opening, 1¼ inches; width of valve slide opening, ⅝ inch; length of connecting rod, 9 inches; diameter of shaft, ½ inch; diameter of eccentrics, 2 inches; diameter of fly-wheel, 5 inches; extreme width, 6⅝ inches; extreme length, 18⅜ inches. A model may be made far more simple than mine and serve the same purpose as one more elaborate in appearance. The design and general construction may vary to suit the taste of the maker or test his stock of patience and skill and also the limit of time he may have to devote to the task.

NAVY ELECTRIC GENERATOR SETS

Rigid Tests Required by the United States Government.

All the generating sets for the United States Navy are subjected to special tests, consisting of a four-hours' run under full rated load, at the end of which the machine is immediately subjected to a two-hours' run with 33⅓ per cent. overload. Water rheostats are used to load the generators for the heat and endurance tests, and these, in conjunction with lamp banks, and other adjustable resistances, are used when making the regulation tests.

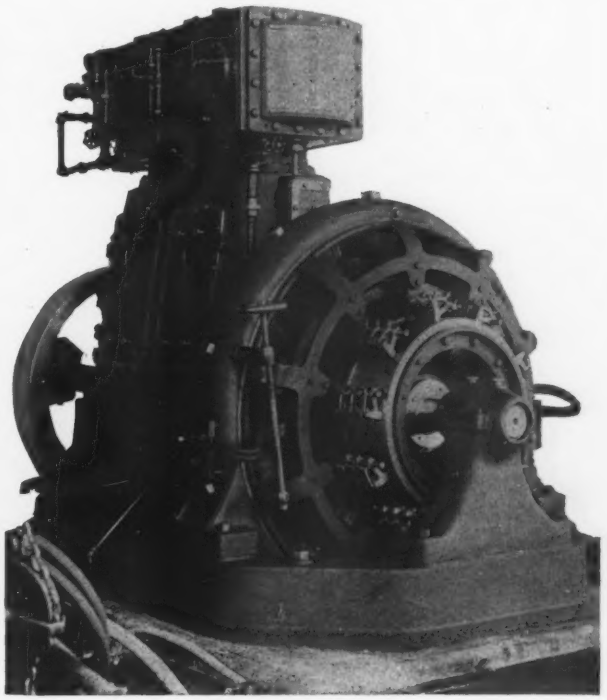
The temperatures rises are calculated from the increase in the resistance of the windings, except in the case of the commutator, armature core and bearings, which are taken by thermometer. The rises in temperature allowed by the government in degrees Centigrade, at the end of the four-hours' run, are as follows:

Armature	33⅓°
Commutator	40°
Field Coils	33⅓°
Series Shunt	40°

the rise in temperature in all cases being referred to a standard room temperature of 25° C. Special stress is placed upon the compounding test of these direct-connected generators, as the Government specifications do not allow the voltage from no load to full load, with any variation in load either up or down, to depart from the specified voltage more than 2 per cent. This feature requires that both the regulation of the engine and the regulation of the generator shall be very nearly perfect. While the heat run is being made, the water consumption of the engine is carefully tested, the steam being condensed in a surface condenser and the water weighed.

The electrical generators of these United States Navy sets are driven by direct connection with engines of the vertical cross-compound enclosed type with detachable hinged oil tight doors on the sides, removable plates at the ends. A watershed partition, between case and bottom of cylinders, serves alike to prevent oil from the reciprocating parts being carried into cylinders and water from the latter being mixed with the oil. This arrangement at the same time allows ready access to the piston and valve rod stuffing boxes while the engine is in motion. Centrifugal oil throwers at the bearings between engine and generator and between engine and governor wheel complete the scheme of oil tightness and guarantee that no oil shall escape along the shaft and into the generator.

There is an oil pump directly driven from the main shaft and located in such a position in the base as to be readily accessible by removing a plate on the bottom of the case, and which supplies oil to all the bearings at an average pressure of 15 lbs., the course of the oil being to main bearings, along shaft, up crack webs to the pins and thence up connecting rod to the crossheads and guides. By this arrangement the mechanical efficiency of the engine is increased to about



New U. S. Navy Vertical Cross Compound Electrical Generator Set

95 per cent., from 85 to 95 per cent. being the best to be obtained without forced lubrication. Speed regulation within 1½ per cent. from no load to full load is secured by the Rites inertia governor and is tested by water pressure. The usual drains are piped to one main drain with by-pass to low-pressure receiver and the relief valves at cylinder ends are arranged to lift from seats to relieve cylinders of water. The cylinders are thoroughly lagged and covered by Russia iron with steel binding. Both the high- and low-pressure valves are double ported and balanced, the high pressure being of

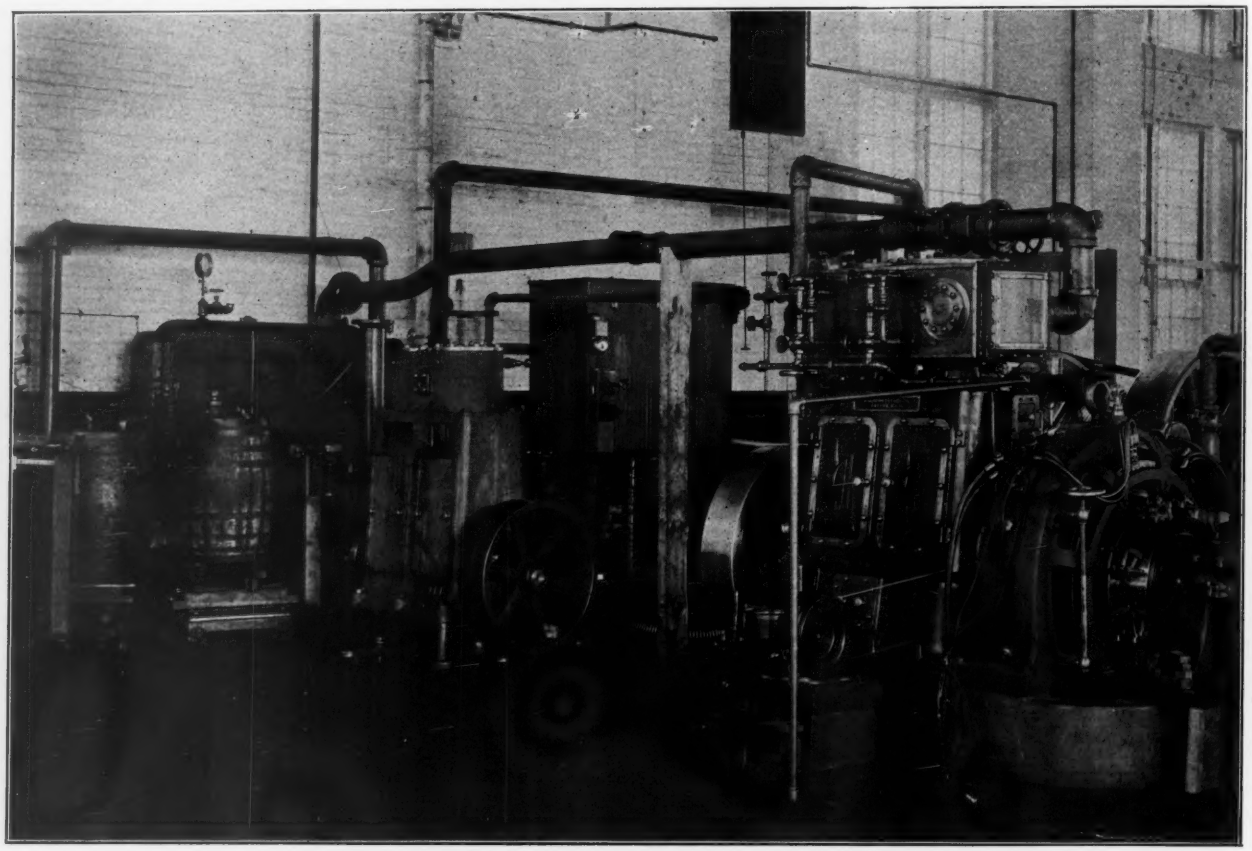
the piston type, and the low pressure a slide valve arranged to lift from its seat for escape of water. Steam and exhaust outlets are placed so that engine may be conveniently piped from either side.

The piston rods are secured to piston by a paper fit and nut and are made of high carbon steel, while the pistons are of cast-iron with specially turned snap rings, insuring a perfect fit in cylinders. Crossheads are fitted with adjustable steel shoes and with bronze boxes for the crosshead pins, which are pressed into forks at ends of connecting rods and dowelled in place. The coupling for direct connecting to generator is forged on the crank shaft, which is made in one piece, of high-grade forged steel with cast-iron counterweights, securely bolted thereto. The cranks are set at 180 degrees. White metal linings in combination with the forced system of lubrication insure a minimum of friction at the main bearings. For examination, the lower half of bearings may be revolved around shaft and removed. The Sturtevant engine, shown in the accompanying illustration, answers these requirements.

A unique feature of this engine is the indicator gear, which is so arranged that cards may be taken without interfering with the oil tightness of case. The reducing motions from crossheads are always in place and automatically engage with short sliding rods which project through stuffing boxes in the side doors.

The dynamos of these Government sets are of the eight-pole type for 50 kilowatts, and ten pole for the 100 kilowatts, the magnet frames being of cast-iron, and are adjustable vertically and split horizontally to allow of removal of upper half for examination of armatures. Shunt and series coils are separately wound and mounted on the pole pieces, which have cast-iron shoes and are through bolted to the frame to allow removal of individual coils.

It will be noted that the armatures are of the iron-clad, two circuit, form wound, ventilated drum type, with cores of special low carbon steel mounted on cast-iron spiders. These have hub extensions for support of commutators and are designed to avoid shrinkage strains and have ample bearing surface on shaft. The laminations are punched from best quality of thoroughly annealed electrical sheet steel, are set up under pressure, and are clamped together in such manner as to obviate all liability of displacement due to magnetic drag, etc. Space blocks are inserted at intervals between laminations to provide ventilation. The armatures are balanced both electrically and mechanically.



Testing Building of the Sturtevant Plant at Hyde Park, Mass.

The electrical generators have commutators which are made up of bars or segments of hard drawn copper, secured on cast-iron shells of spider construction and clamped with steel rings. Insulation between the segments consists of mica, and the end insulation of micanite rings.

The brush holders are of the sliding socket shunt type with flexible connection to each brush and are mounted on studs projecting from brush rigging, and so arranged as to be readily rotated for adjusting brushes. The holders are staggered so that brushes shall wear evenly on commutator and each brush is separately removable and adjustable. Sufficient

brush surface is allowed so that current density will not exceed 30 amperes per square inch bearing surface.

The dynamo insulation receives a 60 second breakdown test of 1500 volts alternating, and shows a resistance of at least one megohm with an initial voltage of 500. The insulation is damp-proof and unaffected by temperature up to 100 degrees C. The generators are capable of carrying 50 per cent. overload for short periods of time, without shifting of brushes or sparking at commutator and will run continuously at 25 per cent. overload without sparking or undue heating. After a continuous run of 10 hours, the heat rise, in any of the parts, will not exceed 40 degrees C. above surrounding atmosphere. Full load may be thrown on or off without affecting the voltage more than 15 per cent.

At the Sturtevant shops, where these units described above are made, a very complete testing plate occupying a ground area of about 30 x 60 ft. is provided in the Testing Building and steam is furnished at any pressure up to 150 lbs. All pipes, both steam and exhaust, together with the condenser connections, are carried in trenches formed between heavy walls which carry and rigidly hold a series of portable cast-iron covers. These are T slotted and individually removable so that pipe connections may be made at any point. The entire plate is served by a 15-ton overhead travelling crane which conveys finished engines or generating sets from the setting up floor to the plates.

It will be noted from the accompanying illustration that a complete equipment of apparatus for conducting endurance and efficiency tests is provided and accommodation is furnished for carrying on several tests at the same time. Most engines require only running test to determine accuracy of adjustment of bearings, and valves and to regulate speed. In the case of a generating set these are made coincidently with the test for electrical efficiency.

THE USE OF COMPRESSED AIR IN MINING

By A. S. Atkinson.

The use of compressed air in mining has become a practical necessity in many parts of the West, and the number of plants freshly installed with air compressors for operating rock-drills and other mining machines is rapidly on the increase. In the Cripple Creek district, in Colorado, practically all the rock-drills are driven by compressed air, and the remarkable developments in this region are chiefly due to this feature of the work. Conditions prevailing in the Cripple Creek region are such as to make almost any other form of drills impossible and costly. Mining has been carried down to considerable depths, and the lower levels consist of rock of unusual hardness and density. Electric drills employed for a time could not stand the racket, and were eventually replaced by air-driven drills. Working depths of one thousand feet have already been reached by the mining companies, but with air compressors installed at the mouth of the shafts, and pipe lines extending down to the various levels, economical operations have been maintained.

The use of air for mining purposes depends a great deal upon the cost of fuel and economical distribution of the compressed air. At the Cripple Creek district coal is high priced, and for this reason attempts have been made at various times to utilize electric power derived from the mountain streams and rivers, but the original cost of harnessing these rivers has kept many mine owners from entering into any such work. The economical use of fuel for air compressing, and the proper distribution of the air pipe lines to prevent loss, have demonstrated the fact that air-driven rock drills depend a great deal upon the management. This may be better illustrated in the statement that the cost of coal for this region varies all the way from 53 cents to $3 per drill shift.

The reasons for such remarkable variation are partly in the difference in the nature of the rocks and the depth of the workings. The cost of drilling the surface rocks or the levels only a few feet down is naturally lower than those located at considerable distance from the compressors, both because of the difference in distance and the hardness of the rock. But by direct-line distribution it has been found that levels one thousand feet below the surface can be drilled at only a slight waste. Care and intelligence in the operation of the compressors and drills are the determining factors after a proper distributing line has been installed.

In two of the mines where straight-line air compressors are used, with single steam and compound air cylinders, some remarkably low results were obtained at low depths. The operation of the plant was carried on for the purpose of ascertaining the relative economy of the air rock drilling. The compressors at the mouth of the shafts were designed to operate ten standard rock-drills at various levels. Extra care was taken to watch the firing of the boilers and the operation of the compressors so that the minimum of fuel would be burnt. Under competent men the test showed that in four months 1,367 drill shifts were operated, and the cost of coal during this time was $1,183.17. But from this must be deducted $450, which paid for coal used in hoisting rock that was removed from the mines. This left $733.17 as the cost of fuel for driving the rock drills. Figured down, this shows only 53.7 cents cost of fuel per shift.

This test was a fair indication of what may be accomplished in a mine where the rocks are of great hardness. In this same district the cost of compressed air rock drills has in the past run up as high as one and two dollars per shift, not because the work was being done at great depths and on very hard rocks, but for the reason that careful operations were not attended to. The workmen and engineers were either careless or ignorant, and the results appeared to prove the costly nature of operating rock drills by compressed air. It is imperative, for the sake of the operation of a compressor plant and mine drills, that competent engineers first design and install the machinery, and then intelligent workmen operate the whole plant. The ordinary miner who operates a drill at a great depth is apt to be careless in handling his machine unless watched by a competent foreman, and in many instances the output of the drills is unsatisfactory because the drills are not properly handled.

In South African mining, especially in the Witwatersrand

district, the use of compressed air has reached probably its highest development. Compressed air was one of the first methods of drilling in this region, and in the past year or two it has increased rapidly. Many old mines which have tried electric power have returned to compressed air. More recently the coal mines of Natal have adopted compressed air on a large scale, and the Rhodesian gold mines have followed the methods of the Johannesburg mines in using this power.

In the latter place the hard surface "banket" gold ore made it necessary to use compressed air drills from the first. Hand drilling was found faulty and costly even on the surface, owing to the nature of the rocks. Moreover, the low-grade nature of the ore necessitated operations on a large scale and at the lowest possible cost. The engineers decided as a result of these conditions that the most economical method was to install large compressors at the beginning and the success of this plan was shown later. In the Johannesburg district, water was scarce and coal quite plentiful. This settled the fuel problem, and with coal within easy hauling distance the cost of air drilling has proved cheaper in this region than elsewhere in the world. Subsequent developments improved the system so that the cost in some instances was brought down to 40 and 50 cents per shift. The scarcity of water demanded special types of engines, and the present practice is to use compound condensing Corliss engines with two-stage air cylinders. In the early stage of the work the boiler practice was uneconomical and not in keeping with the engine practice. Many semi-portable boilers were used to drive compound condensing engines. Today, however, the engineers are installing the most economical boilers they can find without much regard to the initial cost. This in the end pays better than to secure cheaper and unsatisfactory boilers. The early types were mostly of rather obsolete English patterns, but today more American boilers are found than ever before. A number of American manufacturers have sought to design special types of boilers for the compressors which are peculiarly well fitted for conditions which prevail in South Africa. On the whole it may be said that more variety and number of air compressors are in operation in the Witwatersrand district than anywhere else in the world. The question of the most economical and satisfactory compressor may thus be finally settled there. Both English and American compressors may be found working side by side, and as the engineers are displaying considerable interest in keeping a record of their performance, data of considerable value may eventually be collected therefrom.

The best practice in installing air compressor plants demands, therefore, careful consideration of many questions which mine engineers often overlook. The economical operation of the plant must depend largely upon the original designing for any particular place. The number and size of the drills to be used must settle to a large extent the size and character of the compressor, and the nature of the drills is regulated by the character of the rocks. It is uneconomical to use the same type of drills for soft, medium or hard rocks, and also for different levels. There is waste of power to use drills for hard rocks on soft material, and likewise inefficient work to employ drills designed for soft material on hard rocks. Yet frequently such inefficient work is to be found in many mines where the installation has not been carefully worked out on scientific lines in advance. Likewise, compressors too large or too small are found in operation.

The capacity of the compressor to drive a certain number of drills in rocks of a certain density must be rated according to definite rules. The amount of air pressure required may vary from 60 to 100 pounds. Ordinarily, for use at sea level, a pressure of 80 pounds is found the most economical, but if the rocks are unusually hard and stubborn a higher pressure does better work. Usually at the surface level a pressure of 100 pounds is very unsatisfactory, owing to the rapid vibration and the rapidity with which the steel points of the drills are dulled. A factor that must always be considered is the time lost in sharpening and changing drills. This sometimes increases the cost of work upward of 50 per cent.

With an air pressure of 80 pounds at sea level most effective work can be accomplished in the general run of rocks. Economy of operation is obtained by running a number of drills to each compressor, and as the number of drills increases, the amount of air required for each drill decreases. The time when only a part of the drills are in simultaneous operation is always an uncertain factor, but usually it can be averaged at five to ten per cent.

The elimination of waste is one of the most important questions of the day in operating any kind of machinery. This waste may be in the prime mover, the imperfect consumption and burning of coal, poorly-designed grates and boilers, or in the distribution of the power through pipes or lines. In the case of air drills the waste or loss most common is in the distribution of the air through the pipes to different levels. In properly-constructed compressors and pipe lines, the loss in distribution should not amount to more than three or five pounds when air is carried upward of five to ten thousand feet. On the other hand, as the air decreases in density with the height above the sea level, more free air must be compressed at high altitudes than at sea level to give equal results. As an illustration of this, to run three drills at 89 pounds pressure at sea level which require 588 cubic feet of free air for compression, it will be found that at an altitude of 10,000 feet the amount of air required to give equivalent work will be 960 cubic feet. In order to secure the most economical and effective results it is thus highly essential that the engineer in charge should understand the amounts of air required to give equivalent effects at various altitudes. This applies as much to operations in high mountain regions as to deep mining at different levels below the surface of the sea.

In the application of compressed air for mining purposes these factors have not always been properly considered, and as a result a great deal of fault has been found with air plants which had nothing to do with the system or the machinery. A good machine poorly managed cannot give satisfactory results anywhere. Mining companies are slowly awakening to the fact that competent engineers in running the power plants are just as essential as experts in assaying and development the purely technical part of the work. When we reach the point where compressed air plants are managed just as efficiently as other parts of mining, the showing will result beneficially for all concerned. There will disappear then the wide variation in the cost of fuel consumed and operating expenses of each drill shift. There is abundant evidence today that in the best mines air-driven machinery is the most economical and efficient in the industrial world, and that it simply requires equally efficient engineers and operators to produce exact returns on the investments.

PHILADELPHIA'S STREET RAILWAY POWER HOUSES

How Power is Supplied to Carry 1,500,000 People Daily

Upon entering a strange city, there is one thing that usually attracts the stranger, and that is the street railway service. It may be the type of car used, or the cost of the fare, or the method of power distribution, or the good or poor facilities for handling the passengers, but whatever the difference in the transit facilities in the strange town from that of his home city, there are bound to be mental impressions made, either favorable or unfavorable.

The thousands of engineers and visitors to the N. A. S. E. Convention, which will be held in Philadelphia, from September 11th to 17th, will probably be no exception to that rule and while perhaps the smaller details of the transit problems will not interest them, the power problem which enters so closely into the successful operation and which is not generally thought of by the average person, will prove very attractive.

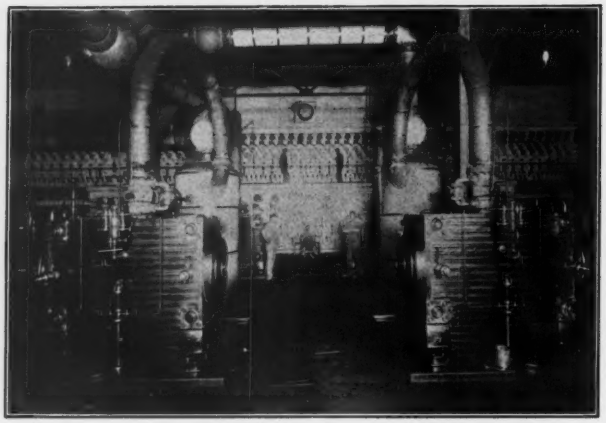
Interior of the Alternating Current Power Station at Second Street and Wyoming Avenue showing 1500 K. W. Turbine Units

All the lines of the city of Philadelphia are operated by the Philadelphia Rapid Transit Co., and the number of miles of track operated by them in the city and suburbs include 554 miles of track, of which 382 miles are single track and 172 miles double track. The rails used on all new construction consist of a 137-pound girder rail. The method of laying these rails has caused considerable attention throughout railway circles and may interest many street railway engineers.

After the rails have been placed on the ties, but before they are spiked, the ends are all thoroughly cleaned by a portable sand-blast apparatus. Two fish-plates of special form, with twelve-bolt holes, are also cleaned by sand blast, and then placed on the rail ends and held in position by two steel drift pins. A steel straight edge is laid on the head of the rail, and the tread of the two rails brought to an even surface by wedging. Temporary bolts are then placed in four of the holes in the rails and plates, and the remaining holes are reamed out to $1^{1}/_{32}$-in. diameter by a portable pneumatic reamer. The twelve rivets are then driven home by a portable pneumatic riveter, clamping the plates solidly to the web of the rail, but leaving, owing to the special shape of the plates, a space under the head, the tram and around the foot of the rail. Iron clamps furnished with asbestos cloth pads and clay dams are then placed in position, and the whole joint is warmed by fuel oil burners to a temperature of from 300 degrees to 400 degrees, after which molten zinc is poured into these hollow spaces. The claim is that the introduction of this metal in a fluid state fills up the smallest interstices between the fish-plate and the rail, giving a continuous solid bearing throughout

which is impossible with the ordinary fish-plate, while the crystalline nature of zinc prevents any flowing or peening under continuous shock and vibration. It is also claimed that the zinc when poured on the hot, clean, metallic surface of the rail and plates will practically amalgamate with them, and give a true electrical joint, into which water and corrosion will not penetrate.

In setting the rails, the horizontal trench is first excavated and surfaced. Temporary cross-ties are then supported transversely in this trench, and the rails are laid thereon and roughly brought to gauge. For these temporary ties it is customary to use a cross-tie consisting of a wooden body surmounted by a metal channel member suitably secured thereto, and of a length greater than that of the body portion. The overhanging ends thus produced facilitate the adjustment and attachment of the rails, while the body portion is adapted to the operation of surfacing the rails by tamping up under the tie. The rail is clamped to the end of these temporary ties by means of clips and nuts. Having secured the rails to the temporary ties, the side trenches are dug, the yokes or anchors hung upon the rails, and the concrete filled in. In this part



Several of the 1500 K. W. Direct Current Units at 13th & Mt. Vernon Sts.

of the process shims are interposed between the rail foot and the head of each yoke. In finishing the work, these shims, as well as the temporary ties previously mentioned, are removed, leaving the rails raised from the yokes, but adjustably held down upon the concrete by bolts passing down through the holding blocks.

The total number of passengers carried during the last year approximated nearly 450,000,000, from which the gross income was about $18,000,000. To carry all these passengers and to do other special work required about 3,600 cars, of which about 2,000 are closed cars and 1,300 are open cars, the remainder consisting of sprinkler cars, ploughs, sweepers, sand cars, freight cars, rail cars, mail cars, testing cars, parlor cars and money cars. The principal type car now being put in use is a 38-foot car of the Brill semi-convertible type mounted on double trucks. Each car has four motors of various types and is equipped with Christensen air brakes.

To generate power for the various city and suburban lines, 11 power houses are used, the more important ones being situated at Thirteenth and Mt. Vernon Streets, Delaware Ave. and Laurel Streets, Thirty-third and Market Streets, and Second Street and Wyoming Ave. All the plants are direct-current plants except the Second Street and Wyoming Ave. plant and the new plant at Delaware Ave. and Laurel Street, which is now being built to replace the direct-current plant there.

As early as 1903, the engineers of the Company recognized the value of alternating-current distribution for street railway service and erected a temporary plant at Second Street and Wyoming Avenue, with 2,000 kilowatt capacity and erected three transformer and rotary sub-stations at various parts of the city. The next year the station was enlarged with the addition of four 1,500 kilowatt Parsons alternating-current units and three additional transformer sub-stations were erected. This method of distribution having proved so successful, a permanent plant is now being erected which includes all the old units and two additional 1,500 kilowatt Parsons turbine units.

The construction of a new subway and new elevated lines has demanded a large power house near the centre of the city, so that a new 55,000 kilowatt central alternating current station is being erected at Delaware Ave. and Laurel Street on the Delaware River. In connection with this plant there is now being erected a large sub-station in the centre of the city, at Ninth and Sansom Streets, which will ultimately have a capacity of 12,000 kilowatts. The new alternating and the old alternating stations are about 6 miles apart, but they will be tied together with underground alternating current mains, the bus-bars of the two stations being connected in parallel so that either station can supply any or all the sub-stations.

The voltage generated by the alternating current generators is 13,200 volts, three-phase, 25 cycles and is transmitted at the initial voltage, where it is transformed and converted to the regular 550 volt direct-current used in street railway practice. The longest transmission at the present time to the furthest sub-station is something over 9 miles.

The eleven generating stations have at the present time a combined generating capacity of 47,600 kilowatts, of which 36,600 is direct-current and 11,000 is alternating-current. There are ten sub-stations having at present a combined capacity of 14,000 kilowatts in rotary converters and six storage battery plants having a total capacity of 5,200 ampere hours.

The centre of the city is supplied from the direct-current station located at Thirteenth and Mt. Vernon Streets. It is equipped with five 1,500 kilowatt Westinghouse direct-current generators directly connected to Wetherill horizontal cross-compound Corliss engines. The building is of fireproof construction, along one end of which the switchboard runs the entire width. The switchboard is arranged with upper and lower bus-bars. The lower bus-bar is continuous throughout the whole board and in ordinary operation all feeders leading from the station are connected to the lower bus-bar. The upper bus-bar is divided into five sections, any of which can be connected if desired. From four of these stations heavy cables connect to four other power houses, so that the load on any power house may be varied and the engines run at their most economical load.

The particular feature of this plant is the installation of two low-pressure Curtis turbines. These turbines are 1,500 kilowatt capacity each and utilize the steam between the exhaust pressure of the reciprocating engines and the condenser vacuum. Each turbine generator generates direct-current and floats on the line, automatically taking its share of the load.

Steam is taken into the turbine at about 15 pounds pressure absolute and is exhausted into the condenser at about 1 pound absolute.

The boiler room is equipped with nineteen 375 horse power Babcock & Wilcox boilers and one 400 horse power Parker boiler, the boiler pressure being 145 pounds. These boilers are hand fired. The coal used is brought to the station in wagons and after passing over weighing scales is dumped from the bottoms of the wagons into the hopper of a coal elevator. This elevator carries the coal to the top of the boiler room, where by means of chain conveyors it is distributed along and into a suspension bunker. From the bottom of this sheet-steel bunker tubular chutes direct the coal to the floor of the boiler room in front of the boilers. The ashes fall from the grates into pockets and are loaded into cars operating over a runway below the boiler-room floor. These cars are pushed along the runway to two automatic ash elevators built at one end of the boiler room. The type of ash elevator used here is novel in that it requires no handling except the starting on the up trip. The ashes from the collecting car are dumped into the bucket and the elevator is started by pulling an end rope in the ordinary manner. When loaded and started the elevator requires no further attention. The bucket carrying about 1,000 lbs. of ashes is raised to the top of the elevator which automatically dumps the ashes into a storage bin, rights itself and returns to the starting-point at the bottom of the elevator shaft. From the pockets on the under side of the ash storage bin the ashes are loaded into specially constructed cars which have a capacity of 20 tons each and are used for collecting and distributing ashes from the several generating stations throughout the city. Two duplex Buffalo feed pumps, 16″ x 9″ x 24″, are used for pumping the feed water which goes through a 5½′ x 9′ open heater.

The power station at Delaware Ave. and Poplar St., known as Station No. 2, is a condensing plant and contains four 1,000 horse power Porter Allen engines, one 300 horse power Porter Allen engine and one 1,000 horse power Wetherill Corliss. The larger engines are connected to General Electric dynamos, while the smaller is direct connected to a Westinghouse generator. The boiler room contains 14-250 horse power Babcock & Wilcox, which operate at 145 pounds steam pressure. Two Worthington duplex, 10″ x 16″ x 8½″ x 10″ pumps are used for the feed water. The condensers used are of the jet type, there being one Blake of 16 x 32 x 21 and one Blake 12 x 25 x 18. Broomell, Schmidt & Stacey economizers are used and mechanical and steam blowers are used for draft.

The power house at Beach and Green Sts. is equipped with three 1,500 kilowatt General Electric generators connected to E. P. Allis twin tandem-compound engines; also one General Electric 500 kilowatt generator connected to an E. P. Allis single-cylinder engine. In this station are two engine-driven boosters and one motor-driven booster for use on some long feeders supplied from this station. The boiler room is on the second floor and is equipped with 12 Babcock & Wilcox boilers and two Thayer boilers. This boiler room is the only one in the direct-current stations which is equipped with stokers. This station is operated condensing. The condenser system includes one E. P. Allis direct-driven pump which draws the water through the condenser headers for all the units.

The station at Thirty-third and Market Sts., or Station No. 4, is equipped with four Westinghouse 1,500 kilowatt direct-current generators, two of which are direct-connected to Wetherill cross-compound engines and two to Pennsylvania Iron Works Co. engines. There are also two smaller engines

Sub-Station at Eight and Sansom Streets equipped with Transformers and 1500 K. W. Rotary Converters

of this latter type connected to 800 kilowatt Westinghouse generators.

This power house was originally a non-condensing station and has recently been changed to a condensing station by installing Barnard cooling towers. These are located on the roof of the boiler house. The exhaust from the engines is led to three surface condensers but no attempt is being made at the present time to use the condensed water. Water for cooling is taken from the city mains and after passing through the condensers, as much as is needed is automatically divided and taken for boiler-feed purposes at an average temperature of 120° F. The rest of the circulating water is forced to the cooling towers by centrifugal pumps driven by De Laval steam turbines. The cooling towers are each equipped with two fans driven by a 40 horse power motor. Each of the five cooling towers is fitted with two 10-foot fans. This equipment cools water to condense 180,000 pounds of steam per hour. Two surface condensers, each having 9,000 square feet of condensing surface, are used, the air pumps for this installation being of the Edwards type. The pumps are 8 x 12 triplex and are driven by two 40 horse power motors. The cooling towers are arranged with doors at the bottom so that in winter the fans, which are driven by belted motors, are disconnected and the tower is operated under natural draft.

The boiler room contains sixteen 375 horse power and one 500 horse power boiler of the B. & W. type and two 375 horse power boilers of the Parker type. Coal is delivered to this station by wagons and, after passing the scales, is dumped into the hopper of an elevator. When elevated, the coal is distributed by a rope conveyor into a suspension coal bunker. The ashes are taken from the ash-pits beneath the boiler and are carried to concrete ash storage bins by an automatic elevator. The bins are fitted with under pockets which allow the special ash collecting cars to be loaded.

Station No. 5, at Thirty-third and Dauphin Sts., is equipped with three 1,000 horse power Wetherill Corliss condensing engines connected to two Bullock and one Westinghouse generators. This station is also equipped with 270 chloride cells, having a capacity of 3,200 ampere hours. These cells are operated in connection with the generators and a 125 kilowatt Crocker-Wheeler motor driven booster. The steam from the engines is condensed by syphon condensers, six Wood centrifugal pumps being used for circulating the condensing water. The condensing water is used over and over again by pumping the water through a number of nozzles which spray the water up into the air, after which it falls into a concrete tank built between the two car barns. The station was originally built to run non-condensing but the addition of the cooling pond has enabled it to run condensing. The Ogontz power station, situated about 7 miles from the centre of the city, carries a heavy suburban load and all the cars on York Road which run to Willow Grove. An amusement park, to which from 25,000 to 50,000 people flock daily, is located there and it is controlled by the transit Company. The station is equipped with three 1,200 Allis vertical Corliss engines connected to Siemens-Halske generators. The station is operated condensing, the circulating water is taken from a near-by creek. Owing to the scarcity of water, the water is collected in a cooling pond and used over and over again by spraying the water through nozzles. Jet condensers are used, a Wetherill-Corliss 14 x 16 pump being used to maintain the vacuum and a triplex motor-driven 12 x 14 Deeming pump is used for circulating the water. The boiler room contains nine 250 horse power Berry boilers.

There are four other smaller plants situated in the city and suburbs but they are mostly used for local service, such as for operating the power and doing the lighting for suburban parks and trolleys which the transit Company controls.

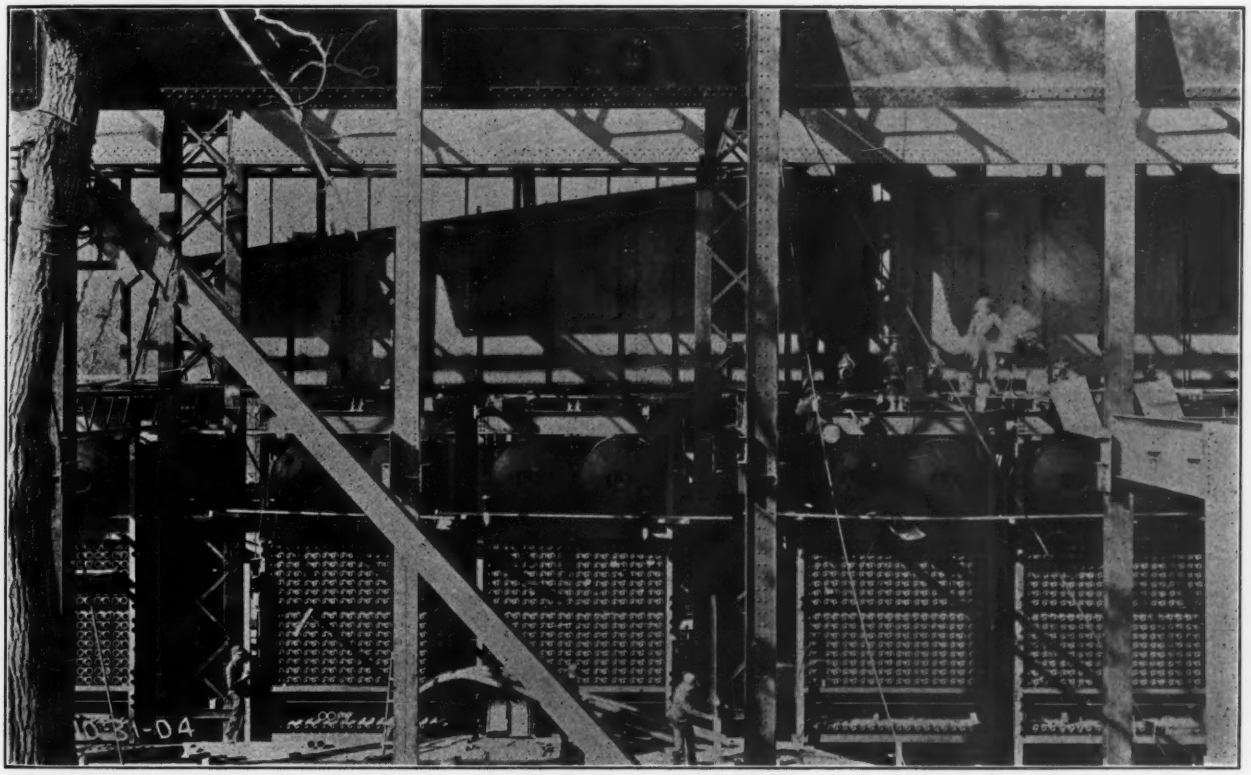
The most interesting station at the present time is the Second and Wyoming Avenue alternating-current station. It comprises an engine room 70 feet wide and 242 feet long and a boiler room 54 feet wide and 267 feet long. The boiler house has a clear height between the floor and trusses of 43 feet and the engine room has a clear height between the machine floor and lower chord of trusses of 26 feet. The boiler equipment consists of 16 Parker, double-end, water tube boilers of 700 horse power capacity, generating steam at 150 pounds pressure. Parker superheaters are installed with this boiler equipment which adds about 100 degrees superheat to the steam. The boilers are arranged in a single line with a stack near the middle of the boiler house dividing the row of boilers into two batteries. These boilers are equipped with Box stokers for feeding the two sets of grates. Each row of eight stokers is driven by two Westinghouse 10 horse power enclosed motors. Each of the motors is connected to four of the stokers and a coupling permits the driving of eight or the driving of four with one motor. The ashes drop on an inclined plane of firebrick which leads to an ash-hopper under the centre and parallel to the fronts of the boiler. The ashes accumulate in the hopper, from which they drop by gravity into a car standing underneath. This car is pushed along a track to an elevator outside the boiler house and by means of an elevator, the ashes are carried to a concrete storage hopper from which they are emptied into the Company's 20-ton cars.

The coal is brought to the station in railroad cars and is dropped through a screen into a coal receiving hopper. From this hopper the coal passes through steel pipes to the hopper of a coal elevator. By means of this elevator, which has a capacity of 60 tons per hour, the coal is raised to an automatic coal weighing machine. From the weighing machine the coal is fed into a horizontal conveyor operating throughout the entire length of the monitor, which forms part of the roof system and extends throughout the length of the boiler house. At suitable points the coal is allowed to drop into a suspension coal bunker from which the coal is lead by means of 12-inch steel pipes to the stoker hoppers on the double-end boiler fronts. Natural draft is used, the flue gases being drawn off by a stack 220 feet high. It is constructed of plate steel with a lining of firebrick and is 16 feet inside diameter and 22 feet outside diameter.

The main steam header which has an outside diameter of 14 in. and walls $^{7}/_{16}$ in. thick with rolled steel flanges and extra heavy cast-iron fittings is 17 ft. 3 ins. above the boiler room floor and extends along the boiler room side of the partition wall. Fourteen-inch gate valves divide this header into four sections. Each boiler feeds into the top of the header through a long radius bend pipe. In each of these boiler connections are a gate valve and a stop check. Steam for the main units is led from the lower side of the header through angle valves and long radius bend pipes extending through the partition wall to the throttle valves.

The generating units include two Wetherill-Corliss hori-

zontal cross-compound engines rated at 1,500 horse power. These engines have cylinders 28 inches and 56 inches by 48 inches in size. Mounted on the shaft of each of these engines is a G. E. 1,000 kilowatt, 3-phase, 25-cycle, 13,200-volts alternating-current generator. In the steam connection to each of these engines is a receiver, but as the steam is generated at about 100 degrees superheat, their separating function is not needed but they act as receivers in the steam line, thus lessening any pulsation in the steam. Vacuum on the low-pressure cylinders of the two engines is maintained by means of a barometric condenser. Two 30 horse power motor-driven centrifugal pumps furnish water for this condenser. The cooling water is taken from a creek nearby, and after the water has been used, it is returned to a cooling pond. The bearings of the two engines are equipped with fittings of a gravity oiling system. Drips from all the bearings are led to a well, from which a steam pump raises the oil to a combination tank and filter located near the roof of the engine room. The oiling system and filters in this and all the traction Company's power houses are of the American "Unit" type.



Double End 800 H. P. Parker Boilers at Second Street and Wyoming Avenue Power House

The turbine outfit includes six 1,500 kilowatt Parsons turbine, two of them being of the two-stage and the other four of the single-stage type. Each turbine runs at 1,500 revolutions per minute and drives a 13,200 volt alternator of 1,500 kilowatt capacity. The speed of the turbine units is controlled by governors which may be electrically regulated from near the main switchboard of the power house. The individual condenser for each turbine set is located directly beneath the turbine.

The condensers are of the inverted barometric type. Owing to the limited height at which the condensers are placed above the water level, the customary tail pipe could not be used, but is replaced by a 12-inch centrifugal pump which produces the same suction effect as the water column in the tail pipe. This keeps the condenser clear of water although the bottom of the condenser is only about 10 feet above the water level in the discharge conduit. Injection water is brought into the building by a concrete tunnel under the engine room floor and is lifted into the condenser at a height of 18 feet above intake level by the vacuum established by the operation of the two dry-air pumps. These pumps are on the engine room floor and are of the horizontal Corliss two-cylinder type with cylinder dimensions 10 x 24 x 24 x 24 inches. These pumps operate continuously while the condenser is in use and serve to remove any gases or vapors which are not removed from the condensers by the centrifugal pumps. The centrifugal pumps of these condenser sets are designed for removing water from the condensers under vacuum and are belt-driven from extensions of the turbine shafts. Steam for the operation of the dry vacuum pumps is taken from the main steam header.

There are four boiler feed pumps; two of these are of the Scranton horizontal duplex outside packed plunger type with cylinders 12 x 7½ x 12 in size, while the other two are of the Heissler duplex triple expansion type with 6" x 14" double-acting cylinders. Boiler feed-water is taken from the condenser discharge at the pond at one end of the boiler house, which for cooling purposes is equipped with fifty 3-inch spray nozzles. All the boiler feed is heated in a 15,000 horse power open heater, which utilizes all the exhaust steam from the power station auxiliaries. The steam drips from all parts of

the engine room are collected in a tank in the basement and forced back to the boiler by a duplex steam pump governed by a float in the drip tank. An automatic blow-off is also installed in case the drip pump is inoperative.

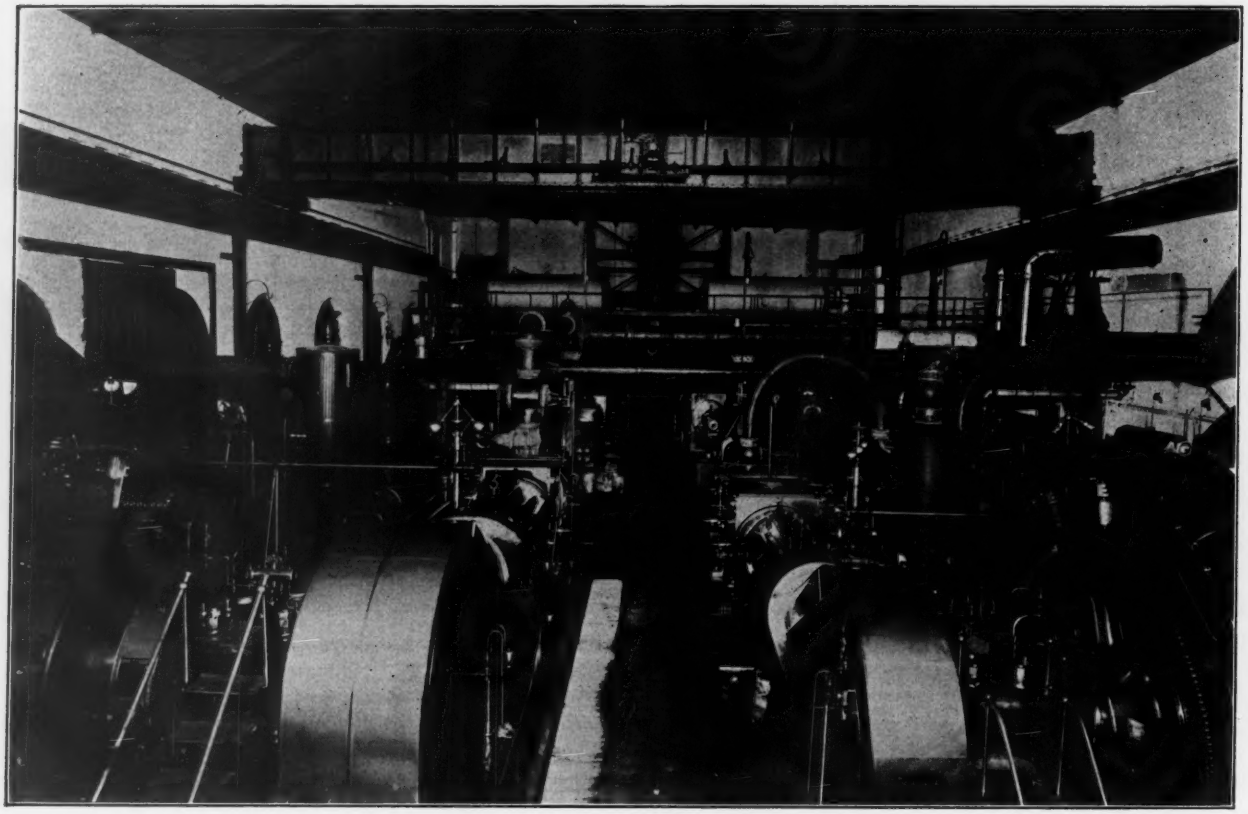
The exciters for the alternating-current generators are generated by three De Laval turbine sets, which, however, are now being replaced by reciprocating engines. The exciters are each of 375 kilowatt capacity and generate 125 volt direct-current. The new engines being installed are of the horizontal type, with cylinders 13 x 14 inches in size. These engines are direct-connected to 100 kilowatt 125 volt direct-current generators, which run at a speed of 125 revolutions per minute.

From each of the 3-phase generators, the alternating current at 13,200 volts is led in cables to motor operated oil switches built into the structure of the bus-bar compartments. This structure contains machine switches, line switches and sectional switches and is made of red brick and soapstone.

From the machine switches the current passes by means of separate cables for each phase through individual compartments to the main bus-bars. These bus-bars can be divided into sections by hand-throw knife switches mounted on glass pedestals cemented into the soapstone barriers. The current for the outgoing high potential feeders is taken through single-conductor cables in individual cells connecting the bus-bar compartments with the proper cells of motor-operated line switches whose walls form a part of the general bus-bar structure. From each of these line switches the three conductors enter the terminal bell of a standard underground lead and paper insulated feeder cable, which leaves the building through underground ducts with openings in the power house foundation wall directly under the line switches.

The bench board for the control of these motor-operated machine and line switches, together with the marble panel switchboard for the instruments and for switching of all direct- and low-voltage current, is located opposite the reciprocating engine units. On the bench board are the control switches for all motor-operated machine and line switches, the control switches for the governors on the generating units and the control switches for the motors operating the shafts of the field resistance boxes of the alternating-current generators. The top of this bench board is of gray marble and is equipped with red and green pilot lights for indicating the position of the machine and line switches.

The switchboard consists of 41 marble panels about 8 feet high by 20 inches wide. These panels are fitted with the indicating instruments and trip coils for the alternating-current generator and feeder switches and also the control switches,



Interior of Direct Current Generating Station at 33rd and Market Streets

circuit breakers, rheostats and instruments for the direct-current generating units, the exciters, the motor operated oil switches, storage battery and the several auxiliary lighting and power circuits throughout the station. The synchronizing instruments are mounted on a separate panel directly over the alternating-current machine panels.

As has been described, the present power station on Delaware Avenue is a direct-current generating station but in a short time a portion of the new 55,000 kilowatt alternating-current generating station, erected on the same site, will be ready for service. The new building is being erected in two

portions and when the present portion is finished, the old station will be torn down and the whole of the new station completed. There will be installed in the completed station, eight turbine generating sets, the north three of which will be of 6,000 kilowatt capacity each and the other five of 7,500 kilowatt capacity, each generating alternating current at 13,200 volts. These turbines which will be of the single-stage type will stand on the reinforced concrete floor at an elevation of 26 ft. 6 in. above the basement floor. A condenser set for each turbine will be installed on the basement floor directly under the turbine which it serves. Ten feet below the basement floor is the top of a pair of intake conduits which extend throughout the length of the engine room under the line of turbines. Each of these conduits has a cross-sectional area of 7 x 9 ft. Parallel with intake conduits and about ten feet distant is the discharge conduit which is 9 x 12 ft. in cross-section. These intake and discharge conduits are built of reinforced concrete and are rectangular in section. They extend along under the engine room serving each of the condenser sets and turn to the east near the north end of the building, passing out under the pier to their gates on the river front.

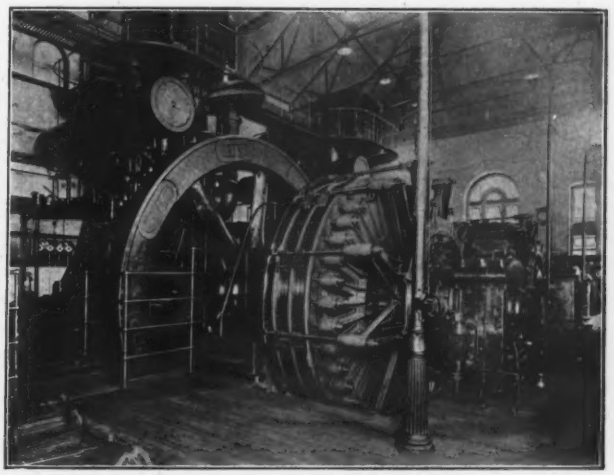
In the gallery along the Beach St. side of the basement will be built two rows of bus-bar compartments. On the main floor will be the turbines mentioned, the exciters and the oil switch compartments which will be built in a row parallel and near the west building wall. The bay in which these oil switches will be placed will be served by an overhead crane mounted on runways supported by reinforced concrete stringers built as a part of the outer wall of the engine room and the row of columns dividing the current handling compartments from the turbine room proper. The first gallery above the oil switches will contain the main switchboard for the power station and the gallery directly above this will be occupied by the rheostats. An overhead crane of 60-foot span will operate on runways the entire length of the engine room.

In the boiler room and at a position opposite each of the turbine sets will be the battery of boilers supplying steam. Each battery of boilers will be made up of eight 1,000 horse power water-tube units set side by side in rows across the boiler house. Over the top of each of these batteries will be a sheet steel breeching leading the smoke to the bottom of a stack. The eight independent stacks, one for each battery of boilers, are of reinforced concrete construction mounted on a grillage supported on lattice steel posts directly over the middle of each row of boilers. These stacks have an inside diameter of 14 feet at the base.

To run all the power houses and sub-stations requires 430 men, of which 303 are employed in the generator stations and 28 in the sub-stations, the remainder being steam fitters, machinists, bricklayers, carpenters, electricians, etc. The average station has one engineer in charge, two assistant engineers, one first oiler, nine oilers, three switchboard men, three generator men, three water tenders, fourteen firemen, one boilerman, one coalman, two ashmen and three boiler cleaners.

The total power station output is constantly increasing but recently it was 138,489,620 kilowatt hours, total No. 1 Buckwheat coal required to produce it being 574,539,522 pounds. Cylinder oil required for the whole system was 2.66 gallons per 10,000 kilowatt hours or 19.8 pounds. Engine oil used, average for the whole system, per 10,000 kilowatt hours, was 1.57 gallons or 11.6 pounds. Pump and engine repairs, per 1,000 kilowatt hours, cost 13.98 cents; pipe repairs per 1,000 kilowatt, cost 10.74 cents; packing and waste per 1,000 kilowatt hours cost 3.86 cents; boiler cleaning per rated horse power cost 80.05 cents; boiler setting repairs per rated horse power cost 28.66 cents; boiler repairs per rated horse power cost 48.18 cents; total boiler cost per 1,000 kilowatt hours 118.34 cents. The labor cost per 1,000 kilowatt hours in the power houses was 129.8 cents and for sub-stations 8.4 cents or a total of 138.2 cents. Cost of handling ashes per 1,000 kilowatt hours was 16.64 cents; cost of water per kilowatt hours was 11.15 cents; cost of electrical repairs and supplies per 1,000 kilowatt hours was 18.16 cents and repairs to economizers and heaters, supplies, tools, betterments and miscellaneous cost 17.73 cents.

The scheme of power distribution centres in the 11 generator stations, six rotary converter stations and four storage battery stations. There are also several new sub-stations being built. The underground distribution of power includes over 1,000 miles of cable for distributing the current used in railway operation. This cable is laid in vitrified clay ducts. These are built in single-duct formation and are surrounded by a protecting wall and bed of concrete 3 inches thick. The standard manholes are 9 feet long and vary in width and depth



Interior of Ogontz Power House showing 1200 H. P. Allis Corliss Engines and Siemens-Halske Generators

to suit local conditions. Terra cotta drain pipes connect these manholes with the sewers. The entire system of manholes is inspected and cleaned regularly, each manhole being cleaned thoroughly at least every two months.

Each rotary converter substation is connected with the alternating generating plant by two or more high potential cables which are of the three conductor type and vary in size from No. 0 to No. 0000. The insulation on high-tension cables consists of 3/8-inch saturated paper wall around each conductor and a 3/8 saturated paper belt around the three conductors, which are twisted together. A lead covering 1/4-inch thick protects this core. The working voltage is 13,200 volts difference of potential across the phases of the 3-phase alternating-current circuit. Before such cable is installed for service it is subjected to a test of 26,000 volts. As any cable is of sufficient conductivity to operate the sub-station which it serves, but one of the two cables serving any sub-station is

in use at any one time. Each cable is put into service every other day and is out of service on alternate days. This arrangement insures maximum safety from breakdown.

The only high potential lines that are carried overhead are those in the section from the Glenside sub-station to Willow Grove, which is practically through country. This line consists of three No. 0000 7-strand aluminium cable supported by 8-inch triple petticoat brown porcelain insulators. The wires are at the vertices of an equilateral triangle 42 inches apart.

For the direct-current service, the standard sizes of cables are 1,000,000, 1,500,000 and 2,000,000 circular mils. The standard cable at present being used consists of a copper core of the desired cross-section insulated by $^5/_{32}$-inch of saturated paper with a $^5/_{32}$-inch wall of lead. In power houses and sub-stations this cable is brought direct to the switch terminals on the board. The network of trolleys throughout the city is divided by means of line circuit breakers into a large number of independently fed sections which vary in length of trolley wire fed from 2,000 to 5,000 feet. Each section has a distinguishing number, which number is also given to the cable from the power house which feeds the section and to the feed tap switches and feeder switches in the power house. Single feeder cables connect the switches on the switchboard in the power house with each of the trolley sections. Taps from the feeder are taken off throughout the length of the section at intervals of approximately 1,000 feet.

In addition to the feeder cables, numerous tie-lines are in use between the direct-current stations. The switchboards of the stations are so arranged that the load may be distributed from any heavily loaded station to other stations connected with it. These tie-lines are also especially valuable for maintaining continuity of service in case of breakdowns. The standard overhead trolley construction consists of a span wire supporting the trolley wire between the tops of two steel poles. These poles are built in sections of 5, 6 and 7-inch steel tubing, a 30-foot pole weighing 920 pounds. The standard span wire is a galvanized 7-strand steel cable insulated from the steel poles at its ends by giant strain insulators.

In connection with the underground feeder system, there is installed about 60 miles of telephone cables, which centre in the general office building. The switchboard of this exchange connects about 300 telephone instruments located in various parts of the city. This board connects not only with all car barns, car houses, store rooms and shops, but with telephones at all important street intersections about the city where small telephone sets are enclosed in cast-iron boxes and mounted on trolley poles. Street superintendents are provided with keys for these telephone boxes and are thus enabled to keep in touch with all parts of the system.

Mr. W. S. Twining is chief engineer of this large and well-managed street railway system, Mr. Charles Hewitt is superintendent of motive power, Mr. H. B. Nichols is engineer of way and Mr. A. B. Stitzer is the chief electrical engineer.

PRACTICAL HINTS ABOUT ARC LAMPS

By Wm. Kavanagh.

To the practical man, the history and theory of the arc lamp are not a necessity, but the knowledge of its mechanism and mode of operation are absolutely essential. So long as the lamp needs only trimming and cleaning, the average attendant will ignore its mechanism and in all probability no attempt will be made to comprehend its operation. The moment the lamp fails to light, strenuous efforts will be put forth to try to discover the reason for such failure.

When the lamp fails to light, assuming that it has been properly trimmed, one or all of the following causes may be looked for: 1st. the resistance coil may be burnt out; 2d. the magnet coils may be burnt out; 3d. the frame work may be grounded, thereby preventing sufficient current to flow through the carbons to produce an arc; 4th. broken or grounded connections; 5th. when the movable carbon is continually in motion, thus preventing a steady light; 6th. when the clutch fails to lift the carbon. These six difficulties will be the principal ones met with in practice.

The mechanism of an arc lamp is shown in Fig. 1, and while the shape and construction may vary with different manufacturers, the underlying principles involved in its operation will be found practically the same. Some lamps have their resistance coils wound on separate spools, others have no spools, while still others have their resistance coils wound on one large spool. Again, some lamps are fitted with two magnet coils while other lamps are only fitted with one. The mechanism of the carbon clutch also varies in different lamps, as do the dash-pots employed to resist or counteract the solenoid magnet. The shell or outer casing varies in shape, the methods for taking off and putting on are different; in some arc lamps, the resistance coil must be removed before the outer shell can be taken off and in other cases, the shell can be taken off without disturbing the lamp mechanism. Then, again, the method employed to convey the current to the movable carbon is not always the same; some manufacturers solder a flexible wire to the carbon holder of the movable carbon so as to insure this carbon with a positive supply of current, while others depend upon the frictional contact of the carbon holder to insure current supply to the upper or movable carbon.

Referring to Fig. 1, the mains carrying the current are connected to the binding posts A and B. The current flowing through A passes through the switch S and resistance coils R, thence through the magnet M. The current is grounded on the upper frame work of the lamp, as shown at C. The wire B is insulated from the upper frame work of the lamp and this wire is grounded on the lower frame work. Thus it will be seen that the frame of the lamp is divided into two parts and insulated from each other at D. It follows, therefore, that when the carbons are inserted at M′ and N, a passage for the current is provided and if we procure a mechanism to move the carbon M′ upwards or the carbon N downwards, an arc will form between the carbons and light will result. If the

carbons are moved only a slight distance apart, a poor arc will be obtained, accompanied with little light; hence, to obtain a more powerful light the length of the arc must be increased, the amount of which will be dependent upon two factors, namely, the amount of the resistance cut in the circuit at R and the lifting power of the magnet M. If the magnet M is in good order and the arc still remains short, too much resistance is cut into the circuit, which must be lessened by moving the clip at O, thereby reducing the length of the resistance wire. The length of the arc should now increase and consequently a more powerful light should be obtained. If the clip O is moved so as to increase the resistance R, the arc will decrease.

Sometimes, no matter how much resistance is cut out, the arc will not increase in length. In this case it will be found that the magnet M is either wholly or partially burnt out, in which case the magnet must be replaced with a good one. Before discarding the injured magnet, however, it will be a good plan to test it, by allowing the current to flow around it and then by placing a screwdriver or some iron or steel tool against the magnet, its lifting power can be determined. Should the magnet be found strong and therefore not burnt out, then the trouble will be either in the lifting mechanism shown at L or in the dash-pots shown at P and P'.

The object of dash-pots is to resist the lifting of the carbon too suddenly. Should the carbon be lifted with a "jerk," there is a possibility of drawing the carbon out of the field of the arc, thus breaking the arc and no light results. The correct

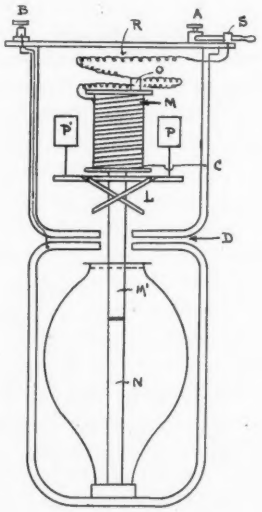


Fig. 1.

working of the dash-pot is an important factor of arc lighting, and to determine if it does operate correctly, it should be seen that it requires considerable force to press the plunger into the pot quickly. From this it is learned that a blow or push will be resisted by the partial compression of the atmosphere, hence the sudden action of the magnet is controlled and the carbon is maintained within the field of the arc and light is formed the moment the contact of the carbons is broken.

Whenever a lamp becomes grounded, the movable carbon sometimes traverses its entire stroke without forming light. Of course, this ground must be removed and the simplest way to do it is to remove the outer shell or casing, then trip the lamp and throw on the current, when the ground should make its appearance and can be easily removed.

When continuous arcing occurs, it will be found that the plungers of the dash-pots are worn sufficiently to permit of a rapid lifting and dropping of the carbon and in such a case as this, satisfactory lighting is impossible. Sometimes the lamp will not burn satisfactorily, although the lamp mechanism and trimming are all right. This is often due to the arc traversing the perimeters of the carbons instead of being central. Impurities in the carbons will cause this and in order to overcome this difficulty, hollow and cored carbons are employed. In the latter case, the centre of the carbons is filled with a soft carbon which is easily vaporized, thus lessening the tendency of the arc to traverse the circumference of the carbons, thereby preventing avoidable shadows. With enclosed arcs, when opalescent globes are employed, the shadows will not be noticeable to any great extent, as this form of globe diffuses the light more equally than clear globes.

It is important to have the upper carbon the hottest, as this will deflect the light downwards. When an arc lamp is first connected to the mains, it may not be wired so that the upper carbon will be the positive carbon. If, however, the current be thrown on and the lamp allowed to burn for a few minutes and then cut off the current, it can easily be seen which carbon is the hottest, and should the lower carbon be the hottest, the lead wires to the lamp must be reversed.

It is sometimes necessary to know what voltage is maintained across the arc. For this purpose, a portable voltmeter can be used and connected to the upper and lower carbons. The arc being formed, the voltmeter will register the necessary voltage to maintain the arc and by connecting the voltmeter to each arc in the circuit and by shifting the resistance in each lamp, an approximate equality of voltage can be maintained throughout the various lamps and each lamp will properly do its share of the lighting.

The length of time a carbon will last depends upon the amount of air which is admitted to it; hence, to prolong the life of the carbon, the inner globe is often made as air-tight as possible. The inner and outer globes should be kept clean, as this will materially assist in the proper diffusion of the light.

General Principles of Engine Efficiency.

Aside from the practical considerations which arise in the construction and operation of any power plant, the following are the general principles of engine efficiency: 1. Steam should be admitted at the highest pressure feasible and exhausted at the lowest pressure possible; this indicates that a high boiler pressure should be used and that it is better to condense the steam than to expel it into the atmosphere, since by condensing, most of the atmospheric pressure can be added to the working range of pressure in the engine. 2. Waste of heat in the engine should be stopped as far as possible; this means checking losses from the cylinder by radiation and conduction and preventing internal loss from cylinder condensation. 3. The work of the engine should be the maximum practicable for its dimensions and use. This secures high mechanical efficiency while the above two conditions secure high thermal efficiency.

The
Practical Engineer

DEVOTED TO THE ECONOMICAL GENERATION AND UTILIZATION OF POWER

PUBLISHED ON THE FIRST OF EACH MONTH BY

L. L. RICE

46 North Twelfth Street Philadelphia, Pa.

Correspondence solicited, and paid for upon publication. Short articles descriptive of the small problems met with in daily engineering practice are especially desirable. Illustrations prepared from pencil sketch.

Subscription Price, Fifty Cents a Year in advance to any Post Office, in the United States, Canada, Mexico or United States Possessions. One Dollar a year to other Countries.

Address all communications and make all checks and money orders payable to

The Practical Engineer

46 North Twelfth Street PHILADELPHIA, PA.

The total circulation of The Practical Engineer for the year 1903 was 77,250 copies, an average of 6437 copies per issue. The total circulation for the year 1904 was 132,000 copies, an average of 11,000 copies per issue. The total circulation for 1905 was 182,500 copies, an average of 15,208 copies per issue.

Any Advertiser is invited to examine our Paid Subscription Lists and Post Office Mailing Receipts at any time.

Entered at Philadelphia Post-office as Second-class Matter

CONTENTS.

	PAGE
Some Principles of Heat	9
Advantages of Multi-Staged Air Compression	13
The Economic Distribution of Steam	14
Navy Electric Generator Sets	15
The Use of Compressed Air in Mining	17
Philadelphia's Street Railway Power Houses	19
Practical Hints About Arc Lamps	26
General Principles of Engine Efficiency	27
Editorials	28-29
Letters from Engineers:	
Examination Questions Should not be Used as Knock-Out Drops to Oust the Practical Man	30
Pump Troubles	30
Thinks Massachusetts License Law Should be Amended	31
Examination Questions Should Deal with the Running of a Plant	31
Young but Wise. Pump Repair	32
Questions and Answers	33-34
Tripp Metallic Packing	34
The Buckeye Gas Engine	35
New England Roller Grate	39
Philadelphia—The N. A. S. E. Convention City	40
Tenth Convention of the I. U. S. E. to be held at Milwaukee	42
Trade Notes	43-44

Correct Indicator Diagrams.

If the many indicator cards which we are constantly receiving show any one thing, it is that the indicator diagrams are often taken from the cylinder of an engine with an incorrect reducing motion. The effect of an incorrect motion is to distort the card so that the different events of admission, cut-off, expansion, release and compression are not recorded correctly and in many cases where the engine valves are performing their functions at the right time, the indicator diagram misrepresents the truth or the card will appear to be a good one when the engine is not working properly.

The latter case is perhaps the most misleading and the hardest to find because every engineer knows what a good card looks like and when the engine is giving that kind of a card, there is usually no uneasiness felt about the valves or valve gear. If the engine is apparently showing a good card and at the same time is also without any doubt showing poor economy, the type of engine is often condemned.

All of these things may seem very clear, when the motion is known to be incorrect, but how many discussions of freak cards and other apparent peculiar happenings about the engine have been the result of a non-synchronous card? When the cylinder of the indicator rotates in exact synchronism with the piston of the engine, then and then only will the indicator record, at the proper time, the proper events which are taking place in the cylinder.

Before taking a card from the engine, the indicator motion should be above suspicion. This can usually be proven by dividing the stroke into some number of even parts and noting if the indicator is moved even distances from one end to the other when the piston is traversing equal distances. In the case of a trunk engine some special device attached to the piston must be used.

Unless the card is taken correctly, it is impossible from its face to give intelligent instruction as to the setting of the valves so that every engineer should be sure that he can rely upon the correctness of his motion before seeking further for any apparent incorrectness in the diagram. There have been many cases where engineers have calibrated the indicator springs and who take metallic cards with metallic points so as to get the minimum friction of the pencil but who have overlooked the way the barrel of indicator receives its motion.

Do not take it for granted that the indicator motion is correct but prove it to your own satisfaction.

—o—

The Electric Locomotive.

An important step in the development of the electric locomotive is promised shortly when the New York Central Railroad expects to move trains by its power into and out of New York City and over about thirty-five miles of suburban lines. Experiments were recently made with two of these electric locomotives on a specially prepared track and they worked to such complete satisfaction that the Company announced its intention to put them and a number of others in service as soon as the power houses and electric equipment are installed. In fact, the Company is so well assured of the practicability and efficiency of the electric locomotive that it is looking forward to the equipment of its main line and branches for this form of power.

The change from steam traction to electric propulsion cannot be made too soon to please the traveller or those living along the railroad lines. The steam locomotive commends itself by its speed and strength, but it has been used principally because nothing better has been invented to do its work. It is dirty, noisy and unpleasant in many ways—so much so that the section of any city through which it runs is always injured as a residence section. The electric engine is clean. It emits no smoke, no gas, no ashes and if it raises any dust, the fault lies in the condition of the track and is not inherent of the method of propulsion. To ride behind it means to enjoy the pure air one finds in an open trolley car and the property along suburban lines will become much more valuable.

That electric traction on railroads has not come sooner is the surprise rather than the events in this direction which are about to be inaugurated. Electric locomotives are familiar objects about coal mines and industrial works where short hauls are required. They have been drawing trains through the Baltimore tunnel for years but the objection to their use for long distances has been the inability to supply them with power. They could not carry their own power because no portable and durable storage battery has yet been made. Before the introduction of the alternating current, they could not be supplied from a power station, owing to the difficulty of carrying large currents long distances and the expedient of erecting power stations at intervals of a few miles was abandoned as too costly. The alternating current motor has only been recently perfected for heavy traction work, so that everything is now at the engineers' command for a successful revision of the electric railroad problem.

If the electric locomotives prove as successful in practical use as they already have experimentally, it can only be a question of time when most of the roads in the United States will be similarly equipped.

The Use of Synchronous Motors.

On commercial alternating-current circuits, one of the main features which is aimed at by all central station managers is the attainment of a high-power factor. A low-power factor means a demand for current quite out of proportion to the output, and hence gives a greater loss in the lines, and requires a greater station capacity than would be necessary with a circuit having a high-power factor. A low-power factor also means a heavy lagging current which makes regulation of the voltage a more difficult matter.

The extended use of induction motors for various commercial purposes has cut down the power factor considerably on many commercial circuits, so that whenever possible, synchronous motors are installed. This type of motor has several advantages which commend it for work of power transmission. At constant frequency it holds its speed absolutely constant, entirely independent of the load and the voltage, except if the load be excessive or the voltage drop too far from normal, when it will fall out of phase and stop. It is practically non-inductive and takes current almost in exact proportion to its load.

The main difficulty with the synchronous motor is in starting. It must either be started by bringing it up to speed with an induction motor and then thrown on the circuit, after which the induction motor is thrown out of action, or else some method such as a special commutator is used to rectify the current applied to the main motor armature, thus giving to it small impulses which give it a starting torque and which bring it up to speed, when the commutator is abandoned and the motor locked in synchronism.

The tendency in synchronous motor practice is, however, toward the use of polyphase machines, in which case when properly designed, they will start as induction motors. When they get up to speed, the field excitation is turned on and they then run as synchronous motors. Since, however, they take a very heavy starting current, they are also generally provided with starting motors, although they are sometimes brought up to speed when the generator which supplies it is started.

For some purposes, the fixed speed may be an objection but for heavy transmission work, they are becoming widely used. They have high-power factors even when used for varying loads and are valuable in neutralizing inductance in the line and the rest of the load. When worked under steady load and excited correctly, they eliminate the lagging current which is generally found in alternating-current circuits.

For sizes under one hundred horse power, the synchronous motor is not generally used as the induction motor is much simpler and far more convenient, since it is self-starting. On many large alternating-current circuits, the general customers of power are required to use induction motors, while the company on various parts of its circuits for its own use, such as for running arc-light machines, or for generating direct-current, use the synchronous motor. The reason for this is that it is dangerous to allow any power user to throw a synchronous motor on the circuit indiscriminately, and since in large sub-stations or where synchronous motors are used, there is usually a trained man employed, the advantages of the synchronous motor in using power economically and in helping along the power factor are made use of.

A synchronous alternating-current motor, therefore, is capable of diminishing or entirely eliminating the inductance of the system to which it is connected and with varying field excitation can produce the same result as a condenser in causing the current to lead the impressed electro-motive force. Thus, a synchronous motor can be made very useful in improving the general conditions of alternating-current transmission.

Under varying loads, the induction motor behaves very similar to the shunt-wound continuous current motor. In both, the armature current is due to the net effect of an applied and a counter electromotive force, the former being delivered from the line through the brushes in the one case and by induction in the other.

Pumps that are exposed to low temperatures in winter should be provided with removable drain plugs or drain cocks for emptying the cylinders and valve chambers of water and also to allow the water to flow out of the suction pipe.

The energy losses in a transformer are due to heating loss in the primary, the heating loss in the secondary and the eddy current and hysteresis losses in the iron core.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

Examination Questions Should not be used as Knock-Out Drops to Oust the Practical Man.

EDITOR THE PRACTICAL ENGINEER:

I have been greatly interested in reading the article in the August issue, by A. E. Rhodes, criticising my former letter about improper examination questions. I am always obliged for criticism, especially when it is adverse, because I know then that it is given with good intention. Besides this, I agree with Mr. Rhodes in a great deal that he says. I say this not that I would retract anything said in my previous letter but that I gave in that letter only one part of what I believe.

In the first place, I don't want to be put in the position of one bucking against progress by removing any incentive that induces any of our fellow-citizens and brother-engineers to improve themselves in a professional or general way. It is an axiom that all improvement in knowledge of the useful kinds is beneficial both to the individual and to the State at large, but, unfortunately or otherwise, many men who have had their training by the rough knocks of experience have grown old in the operation of steam plants. These men can "make the wheels go round" just as well as the man who can construct and figure out theoretical indicator diagrams. No doubt there are also men who can figure the diagrams as easily as they can "make the wheels go round" and who can do this latter as well as the first-named individual. It goes without saying that this class of men have a more broad and general knowledge of the profession than the mere practical operator. If examinations are given to find out this fact, I say, fire away with the theory.

I take it that licenses are issued to protect the public from accidents due to incompetence of operatives in steam plants. In other words, to guard against the explosion of boilers or the bursting of fly-wheels in the basements, for instance, of office or restaurant buildings where such an accident might mean the wrecking of a part of the building with a heavy loss of life. An accident of this kind was the explosion of a boiler in the basement of a hotel in Chicago, not many months since. This accident was not, however, due to incompetence of the management. A dining room directly over the boiler room was simply demolished and loss of life was prevented by the sole circumstance that the accident occurred a few minutes before the time of opening this room for dinner. Possibly this item of "public safety" may not by some be considered one of the prime objects of the license laws, but several of these laws give this as one of the reasons for their existence. Confirmation of this statement may be had by reading the preamble to any of the best city ordinances or license laws of the different States.

Probably many of the grey-haired veterans of the profession could get themselves together enough to acquire the technical training necessary to figure out theoretical diagrams, but many of them who had to struggle for the places they have reached would be compelled to go without the coveted license if this point of theory is considered essential. This could, of course, be called a case of the survival of the fittest, but a citizen of the State (one of those who passed the law) could not feel that his life and interests were better protected than before the practical operator was ousted. Neither could the more accomplished member of the profession enjoy any great comfort in the exercise of his accomplishments when he reflected that they were the means of taking the very bread out of the mouths of those dependent for support on his less fortunate but equally intelligent brother.

Recently I had opportunity to observe that a college graduate and member of the American Society of Mechanical Engineers, who is a man of no mean attainments and who has had about twelve years' experience in office work where such problems as those given in the questions under discussion are worked out as a part of the daily routine, required considerably more time for the solution and construction of the theoretical diagrams, for such a compound engine as that given in the question, than was allowed for the whole examination where it was originally given. Probably one could concur with an examiner's requiring an applicant to sketch in the general form of diagrams that would be given by an engine of any given type, but I am of the opinion that calculations involving hyperbolic and other logarithms and complicated formulas employing the processes of involution and evolution with high powers, smack a little too much of the theoretical to be given in a practical examination.

In order that this letter may be considered in the proper light, will say that I am not one of those to be oppressed by theoretical examinations. I am a comparatively young man and have been through the four years' grind, with its joys and its woes. I have also stood some dozens of these examinations for different purposes and speak from the experience of one who has not been dazed by them when I say that they are a little too "stiff" for the man who has come up in the boiler and engine room through the trying times of our nation's birth and development. Let's take advantage of our opportunities and disseminate theoretical knowledge throughout the profession as rapidly as possible, but not use our accomplishments for knock-out drops to oust the other fellow.

Chicago, Ill. E. S. H.

Pump Troubles.

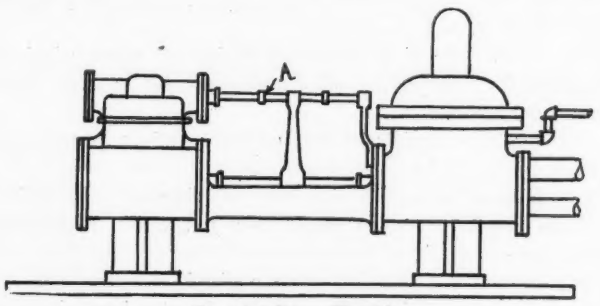
EDITOR THE PRACTICAL ENGINEER:

At one plant I had a steam duplex service pump 8 x 12 x 12 inches. This pump provided water for the service tank for first floor consumption and worked against a pressure of only fifteen pounds.

As this pump ran all the time and as the duty was light, I was somewhat surprised to have a "no water" report come in and find the pump stopped. I gave her more steam, but she wouldn't start, so taking a look through, I discovered that the valve nut on one side was loose and screwed several threads out of position. This threw the valve out so that it

would not admit steam properly. The valve nut in this pump was a single nut on the valve rod, working between the cast lugs on the valve and held to its proper position by a setscrew countersunk into the valve rod. This setscrew had backed out, allowing the nut to move out of position.

At another time the exhaust of this pump was seen blowing on one side, that is, it had three short exhausts and a long continuous blow until the pump made the stroke on that side. I thought it peculiar that the piston should leak so one way and be apparently all right on the reverse stroke. An examination of the steam cylinders disclosed the nuts on one



Cure for Pump Trouble

piston to be loose and backed off about ¼ of an inch, allowing the piston head that much play at each stroke. Tightening the nuts stopped all the trouble and left the pump in its normal condition.

Another pump trouble was with a steam actuated Deane condenser pump. It would be running very smoothly when it would suddenly short stroke for one or two strokes and then return to its regular gait. Occasionally, however, when these short strokes would occur, it would stop, letting the vacuum run down and shutting down the plant momentarily, until the vacuum was caught again. Adjusting the collars on the valve rod did not stop the trouble, but the insertion of leather washers in front of the collars at A, Fig. 1, effected a cure.

Why should the leather washers have the desired effect, when apparently the moving of the collar would produce the same movement of the valve rod and still not produce the desired result? Perhaps some of your readers can explain this seeming freak.

E. Greenwich, R. I. L. L. ARNOLD.

Thinks Massachusetts License Law Should be Amended.

EDITOR THE PRACTICAL ENGINEER:

I am very much indebted to M. H. H. for his answer to some of my questions, but I am surprised when he says that I made a bad mistake by saying that the N. A. S. E. boys seemed not to be able to answer them, for I think his own letter proves that. Facts and figures are stubborn things and if they had been given in the problem, there would have been no need of a discussion; also, M. H. H. knows that the examiner would not stand for an answer obtained from books. If M. H. H. means that by jogging his memory from books he could have answered the questions with very little trouble, I quite agree with him, for I know him to be a good engineer with much ability, but he might have said so, as we are all more or less indebted to books for our knowledge.

I fail to understand why a man should be ashamed to say he don't know or why, because of the gaining of a little knowledge, he should suffer from that terrible, but not necessarily fatal, disease, called the inflated chest. M. H. H. says the question is: "Could these six questions prevent a man from getting a first-class license?" but I don't think there is much cause for argument because I freely admit that they stopped me and as the saying goes "misery loves company", I found out on the night that I submitted these questions to the N. A. S. E. boys that I had lots of company and with all deference to M. H. H.'s knowledge and the other members of our educational committee, they are a part of the company.

From the tone of M. H. H.'s letter, it seems that these questions were the blow that almost killed father and almost wrecked our educational committee, but I don't think their injuries are very serious or that it will be long before they are convalescent. Mr. M. H. H. also says that when he was examined he had about 52 or 54 questions to answer. He must remember he is getting old, for it has been a long time since that and there has been a change in examiners since and also a very big change in questions; so much so that there is as much work, if not more, in answering these six questions as there was in answering the fifty-two or fifty-four that M. H. H. received.

I did not mean to speak disparagingly of the Association, as that was far from my purpose, but I do claim that unless an applicant was studying these questions just before examination, and was given no formula or data to go by, to jog his memory, it would be impossible to answer such questions. No applicant for a license is allowed to hire a team to move his engineers' library into the examination room. He is supposed to be a walking library himself and is expected to be able to answer any old question that an over-educated examiner may fire at him.

I have been watching the peculiar and erratic administration of the Massachusetts license law ever since it was passed and so far as the safety of the public is concerned, it is nothing but a big buncoe game worked on the public, the examiners reaping a harvest from it with the engineers, who have not reached the highest class, as victims. The N. A. S. E. of Massachusetts should put a stop to it by seeking to amend the law compelling the applicant for a first-class license to have at least five years' experience in the lower grades, with the others in proportion.

Fall River, Mass. J. R.

Examination Questions Should Deal with the Running of a Plant.

EDITOR THE PRACTICAL ENGINEER:

After reading "Examination Questions for Steam Engineers," by A. E. Rhodes, page 10, August issue THE PRACTICAL ENGINEER, I have gone over the several letters which evidently inspired Mr. Rhodes to write the article referred to.

Before entering upon any discussion relative to the subject, let us see just what practical means. Webster gives several definitions of the word, but the gist of the meaning is this: "Capable of practice or active use; opposed to speculative," and speculative and theoretical are one and the same thing.

If in the list of questions by J. R., in the May issue of THE PRACTICAL ENGINEER, any of them comes under the head of "Capable of practice or active use," I would like some one to point them out to the readers of this paper. To my mind they

are about as near theoretical as anything can be. In fact, I can't see how they can rightly be called anything else. S. J. S., in the June issue, says they are practical. I am always willing and ready to learn and would, therefore, like to have him demonstrate the practicability of those questions. If there is anywhere a steam plant which has an engineer who finds it necessary to apply the theories set forth in those questions to operate his plant successfully, I for one, would be very glad to hear from him and I have no doubt but that there are plenty of others.

S. J. S. also says: "I believe every engineer should be qualified to answer such questions before he is given a first-class license in this State (Massachusetts) and then the best men would soon be advanced to the most responsible and best-paying positions and would be qualified to fill them." Is this true? I say: "No! not by any manner of means." I have no doubt but that, if a man was capable of answering all such questions, he would be given a first-class license in the State of Massachusetts, but because he holds a first-class license it don't necessarily mean he is the best man for the position or that he can operate successfully the plant of which he has charge.

The writer has in mind two engineers. One could answer all such questions an examiner could ask him, and according to S. J. S., could get a first-class license in his State. The second man could not answer one-tenth of the questions, therefore, could not get a license, first-class, in Massachusetts. The first man can't run an engine and boiler in a steam saw mill successfully, the second man can run successfully, economically and safely the largest steam plant the State of Massachusetts ever had or ever will have, or any other State for that matter. Now, who is the more qualified to fill the position?

Still another case in point. Not far from my town is a trolley road power house and at one time the Company employed an engineer who could answer any of the questions of which I am writing. After about two years' service he left the plant and another man was employed to fill his place. This man could not answer one of these questions to save his life and yet in six months he reduced the fuel bill nearly one-half and was doing the same work. Also the Hartford boiler inspector told me personally that under this man's management the boilers were in better shape than at any time since he had been inspecting them. Who was the better man for the Company? Who was the safer man to operate the plant?

Now for a little attention to Mr. Rhodes. He says in his article mentioned in the beginning of this letter: "It seems to me, however, that the inspector can have a great deal to say about his side of the argument, which will depend entirely upon what his training has been."

I don't know that I quite catch the meaning of this statement, for it would seem to me that the inspector's training should be very broad.

To my mind, a man who had only saw mill training would be a very poor man for an examiner and so on along the line mentioned by Mr. Rhodes. If I understand Mr. Rhodes correctly, he thinks the questions of which so much has been said are the right kind of questions to be asked and answered by an applicant for a license. If I am right in this assumption, I will ask him to place himself in the position of the boy he mentions as applying for the position of assistant to the bookkeeper. Now, before he can secure and fill successfully this position he must answer the following questions: How and of what is the ink made which it will be necessary for you to use? Of what material is the paper in the ledger made and how much of the material was required in its manufacture? What method is employed in ruling the paper? Or the following questions could be asked the boy applying for the position in the printing office: How much paper is required to print 5000 copies of the Sunday edition of the New York *World?* Make a sketch and name and locate the various parts of a specified press used in this office.

Of course, these questions are absurd, but for my part I can't see that they are much more absurd than the questions given by J. R.

The questions which follow are a few of those asked an applicant for the position of Chief Engineer in New York State Institutions.

(1) Explain carefully five causes that might prevent the proper working of a steam pump.

(2) How often would you clean and inspect your boiler? Explain carefully and in detail how you would make such inspection.

(3) How would you line up an engine?

(4) Give three advantages of a feed-water heater?

(5) If an injector failed to work, how and where would you look for trouble?

These are what I would call practical questions and the knowledge necessary to answer them far superior—when the operation of a plant is considered—than those so-called practical questions.

Let me say, in closing, that I believe in an engineer learning the theoretical side of his profession, but let him learn that which will be of some benefit to him in the everyday operation of his plant. When he has thoroughly mastered theory along this line he can, if he so desires, take up the more and deeper theories of steam engineering which will no doubt develop his mind but will serve but very little in bettering the running conditions of his plant.

Poughkeepsie, N. Y. A. K. V.

—o—

Young but Wise. Pump Repair.

EDITOR THE PRACTICAL ENGINEER:

As I am a reader of your valuable engineering paper, would like to say that I consider it a good paper. The more I study engineering, the broader the field becomes, and as I am only a suckling in the *biz* and cannot comprehend strong meat, I especially like the letter department which is very plain and I cannot see why anyone cannot profit by reading the same. The different articles are just fine!

For my part, I enjoy looking over the ads., just the same as the rest of the paper. I am always open for more knowledge whether it is in the letter department, editorial pages or advertisement columns.

We have a cold water Worthington pump that gives us trouble in packing the water end. We could not pack it so it would not leak very badly. Finally, however, I put in a ring of square braid hemp and then wrapped a ring of common belt whang about ½-inch wide around piston and then another ring of hemp and then more whang, and it holds firmly now.

Marion, Ohio. H. H. D.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Horse Power of a Vortex Pump.

EDITOR THE PRACTICAL ENGINEER:

Will you please give, through the columns of your paper, the rule worked out for finding the horse power required to drive a vortex pump whose outside diameter is 36", width 4", diameter of impeller 30", speed 850 revolutions per minute. Suction pipe 6" increased to 10", length 70 feet, discharge diameter 5" increased to 10", length from 200 to 500 feet, gauge pressure at pump discharge 50 pounds, lift 14 feet?

Indian Orchard, Mass. T. G. A.

The makers of the vortex pump give as the economical capacity of the pump, 700 gallons per minute, when the suction pipe is 6" diameter and discharge pipe 5". The total lift through which this water must be pumped is $2.3 \times 50 + 14 = 129$ feet, and the horse power required for each foot lift is .36, so that the horse power required to elevate the water is $129 \times .36 = 45.4$ horse power. Some additional horse power is required to overcome the friction of water in the suction and discharge pipes, the amount of which depends upon the velocity of the water, the number of bends and the roughness of the pipe. The velocity of the water in the 6-inch suction pipe is obtained by dividing the quantity in cubic feet by the area of the pipe in square feet. As there are 7.48 gallons in a cubic foot, the 700 gallons per minute are equivalent to 93.6 cubic feet; the area of a 10-inch pipe is .545 square feet, so that the velocity is 171.7 feet per minute or about 3 feet per second. The loss of head of a fairly smooth 10-inch pipe when the velocity is about 3 feet per second is .4 of a foot for every 100 feet of pipe. There are about 570 feet of 10-inch pipe, so that the total loss of head is 22.8 feet, which is equivalent to the absorption of $22.8 \times .36 = 8.2$ horse power. Assuming that about 2 horse power is absorbed by the water in passing around bends, the total horse power required by the pump will be $45.4 + 8.2 + 2 = 55.2$ horse power.—[Ed.]

Changing Voltage of Dynamo.

EDITOR THE PRACTICAL ENGINEER:

Will you please give me a formula for changing an 8-light 16 candle power dynamo from 50 volts to 8-light 16 candle power 120 volts? It is an Edison drum wound machine. If you could give me a few hints, I would appreciate it.

Jackson, Mich. R. B.

The electro-motive force of a dynamo depends upon three things: the strength of the field, the number of conductors on the armature and the speed of the armature. If the armature is constructed strong enough, increasing the speed to double what it was should give a voltage of 120, in which case it should be capable of supplying 16-16 candle power lamps, since a lamp of 120 volts requires only about ½ of that at 50 volts, giving the same candle power. If, as is probable, the armature will not stand such excessive speed, then increasing the strength of the field would be the next best thing to do. This can be done by adding more coils to the field. Just how many would depend upon the degree of magnetic saturation of the field coils. It would probably require a great deal more than twice the number which are now on the machine. The exact amount would have to be found by experiment. If this is not satisfactory, then there is only one more thing to do, and that is to increase the number of conductors in series on the armature. This means that the armature must be reconstructed but since only one-half the current is required for the 120 volts lamps that was formerly required for the 50 volts lamps, the size wire required is much smaller than that on the machine at present, so that it may be that the practical difficulties are not insurmountable.

The formula on which the above facts are based is as follows:

$$E = \frac{NCn}{100{,}000{,}000}$$

in which E = electro-motive force, N = total number of magnetic lines sent out by the field magnet through the armature and n = the number of revolutions per second.—[Ed.]

Mean Effective Pressure. Perfect Combustion. Dirty Feed Water.

EDITOR THE PRACTICAL ENGINEER:

I would be pleased if you could help me with some of these problems, for which I cannot find any rules.

1. In calculating the mean effective pressure of an engine, why is it insufficient to know what the pressure on the steam side of the piston is?

2. What is the function of the field coils on a dynamo or motor?

3. In what proportion by weight do carbon and oxygen combine to produce perfect combustion?

4. How would you deal with water that was muddy, greasy, or strongly charged with lime?

Phila., Pa. A. W.

1. In calculating the mean effective pressure of an engine, it is insufficient to know what the pressure on the steam side of the piston is because it is just as important to know what the back pressure is. The power given out by the steam depends to a greater or less extent on the amount of vacuum or back pressure above the atmosphere acting on the other side of the piston.

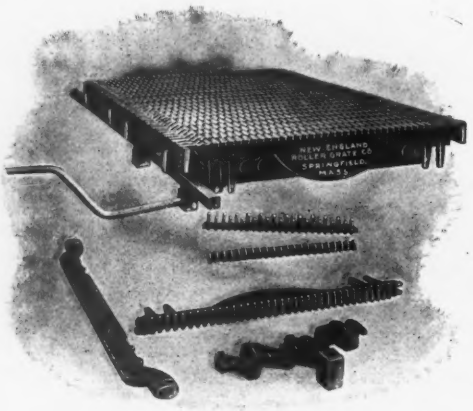
2. The function of the field coils on a dynamo or motor is to so magnetize the fields that they will force their magnetism into the armature. Without a proper field, a dynamo will not generate its proper voltage and without a proper field, a motor will not produce its proper torque.

3. For perfect combustion, each pound of carbon requires $2^2/_3$ pounds of oxygen to burn it, or since there are 23 per cent. of oxygen by weight in the atmosphere, it requires 11.6 pounds of air to perfectly burn one pound of carbon.

4. Try a good automatic boiler skimmer or send a sample of your water or scale to some boiler compound manufacturer for analysis. They will give you a compound which will effectively remedy your trouble.—[Ed.]

The New England Roller Grate.

To obtain the best conditions from any grate, it must possess the general functions of giving adequate support to the coal on it; it must permit the access of air through it from below, which not only keeps the bar cool but furnishes the oxygen for combustion; it must be strong enough to carry the load without sagging or breaking when the fire is at its hottest and it must have its air spaces so arranged as to permit the maximum amount of air through it with the minimum tendency to allow any unburned fuel falling in the ash-pit beneath.



The New England Roller Grate

When these conditions are combined with the shaking feature, the grate permits a greater economy because the fire can always be kept clean and the minimum amount of air is allowed to pass through the fire door, which also increases the life of the fire-box, because it is not exposed to the shrinkage and deterioration caused by cold air impinging upon its heated surface.

The New England Roller Grate, shown in the accompanying illustration, represents a form of shaking grate which embodies the above features. It is built to handle all kinds of fuel, fine or coarse, without waste; its parts are so arranged that it is always level, whether in motion or at rest, and it may be left in any position without risk of burning or injuring any part.

The mechanism upon which the shaking movement depends consists of one piece which reciprocates the bars. There is no weight on this piece as the whole weight of the grate bars and fire is supported by and moved on anti-friction rollers. This allows a positive and easy motion of the bars regardless of the depth and condition of the fire.

All parts of this grate are placed and held loosely in position without bolts, screws, nuts or fittings of any kind, the bars being reversible and all parts interchangeable. There is 50 per cent. air space provided in the grates and the movement of the grate is such that when it is in motion, the air spaces do not vary in size. This grate can be placed under any boiler without change of the fire-box.

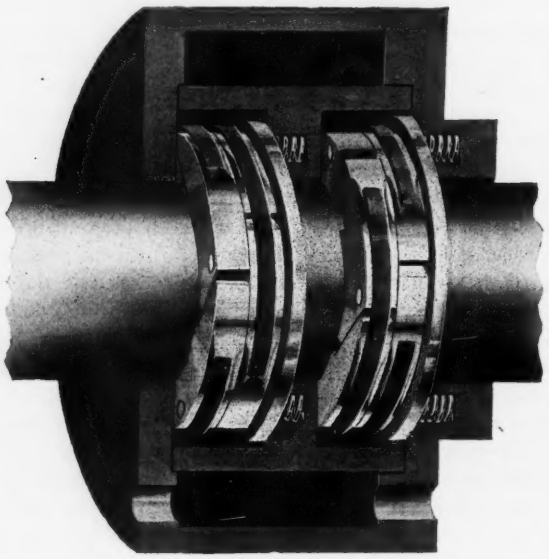
Already the manufacturers have put in 6,000 sets in New England alone and they are now prepared to supply them to any part of this country. For further information address the New England Roller Grate Co., 310 Main St., Springfield, Mass., or their agents, J. B. Hackett, Temple Court Building, New York City, or American Boiler Economy Co., 420 Mutual Life Building, Phila., Pa.

The Tripp Metallic Packing.

The object of all metallic packings is to provide a means of keeping the piston rod tight in the stuffing box with the least amount of friction on the rod, and at the same time, the packing should be capable of resisting both heat and pressure so as to give it long life under the usual working conditions of the engine.

A metallic packing which represents in its construction all the above desirable qualities is shown in the accompanying illustration and is known as the improved type of Tripp Metallic Packing. The packing segment ring is a feature of this packing and was patented on February 6, 1900, from which time the wonderful success of this packing dates.

The segment ring is made of bronze with Babbitt filling, or of solid bronze, as conditions demand. There are four of these rings used around the rod and they are held in place with the next set of rings by means of dowel pins, in such a manner that any unevenness of the rod is at once taken up by the flexibility of the packing. The illustration shows how this form of segment is applied to a double section cage for high-pressure and intermediate pressure rod; both segment rings being adjusted to pack against the steam pressure, the outer segment being used to intercept any condensation that may pass the first one. For low-pressure condensing cylinder rods, the segments can be applied so that the inner ring will pack against the steam pressure and the outer ring against the air pressure, an important consideration where good vacuum must be maintained.



The Tripp Metallic Packing

For further information address Wm. B. Merrill & Co., 74 India St., Boston, Mass., sole manufacturers of the Tripp Metallic Packing.

THE BUCKEYE GAS ENGINE

Latest Type of Gas Engine Built by the Buckeye Engine Co.

Recognizing the need for a reliable and economical engine particularly adapted for direct-coupled generator driving, and fed by suction producer gas or other fuels, such as natural, illuminating and blast furnace gas, gasoline, distillate, etc., the Buckeye Engine Co. has developed the engine described below.

This engine is built in sizes from 25 to 500 brake horse power in the single-acting two-stroke cycle type and in sizes from 500 to 6000 horse power in both the two- and four-cycle double-acting types.

The engine shown in the accompanying illustrations belongs to the two-cycle single-acting scavenging type and consists of two motor cylinders, two fuel pumps and two air pumps. There are two cranks 180 degrees apart, which give two working impulses to each revolution of the crank shaft.

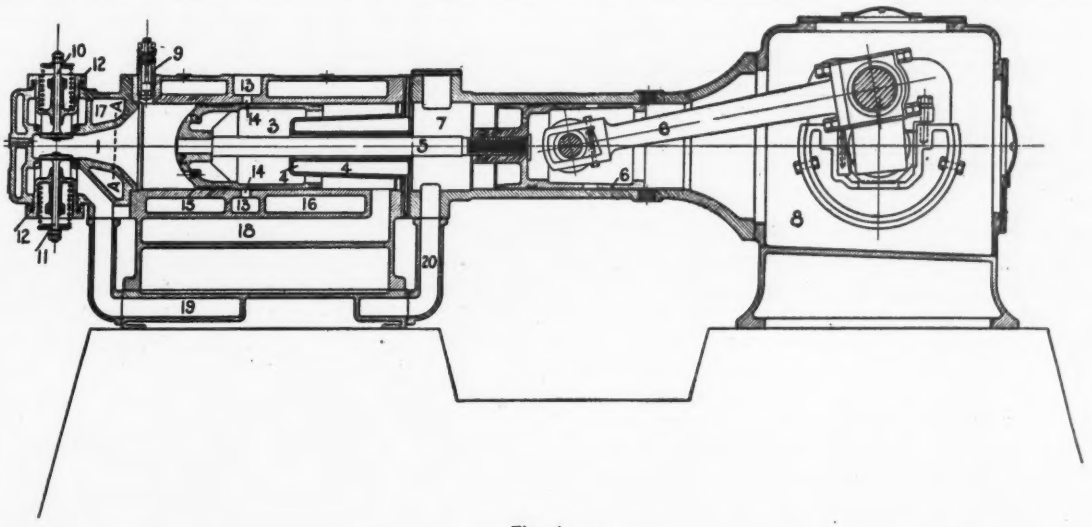


Fig. 1.

The cranks being exactly opposed to which are attached the two pistons of equal weight, the engine needs no counter-weighting and turns at nearly perfect running balance.

Fig. 1 shows the vertical section through one cylinder, one gas and one air pump; Fig. 2 shows the plan of the engine; Fig. 3 is a section through ABCD of Fig. 1; Fig. 4 is a vertical cross-section through the crank; Fig. 5 is a rear-end elevation; Fig. 6 is an exterior view of the engine; Fig. 7 shows the rear view of the valve gear; and Figs. 8 to 12 show the cards taken from a 9 x 12 engine running on natural gas.

The various figures on the cut designate the various parts of the engine. Fig. 1 shows (1) Combustion chamber; (2) Motor piston; (3) Fuel pump cylinder; (4) Water cooled sleeve, separating fuel pump from air and serving as stuffing-box for both; (5) Piston rod; (6) (6) Connecting rod and crosshead, serving also as piston for air pump; (7) Air-pump cylinder; (8) Enclosed crank case; (9) Starting valve; (10) Fuel valve; (11) Scavenging valve; (12) (12) Valve cages; (13) Exhaust chamber; (14) Exhaust ports; (15) and (16) Cylinder water jackets; (17) Cylinder head water jacket; (18) Fuel compression chamber; (19) and (20) Compressed aid ducts.

Fig. 2 shows (21) and (21) Cylinder heads; (22) Driving shaft for igniters; (23) Adjusting device for advancing or retarding the igniters; (24) Bearings for valve cranks; (25) Crank for operating fuel valves (10); (26) Crank for operating air valves (11); (27) Igniter gear; (28) Fuel conduit to right hand engine; (29) Fuel conduit to left hand engine; (30) Right hand piston valve body; (31) Left hand piston valve body; (32) Rock shaft for moving the throttle valves; (33) and (34) Rods for connecting the governor with shaft (32); (35) Bracket for carrying rods (33) and (34); (36) Lay shaft clamped to cranks (25) and (26); (37) Valve rod driving right hand piston valves; (38) Valve rod driving left hand piston valves; (39) Rocker shaft for moving (37) and (38); (40) Crank clamped on (39) and reciprocated by eccentric (41) on crank shaft (42); (43) (44) Right and left cylinders; (45) (46) Right and left crosshead barrels; (47) (48) Hand hole covers forming access to clamping piston rod to crosshead; (49) (50) (51) (52) Covers forming access to wrist-pin adjustment; (53) (54) Man-hole covers on crank case; (55) (56) Hand-hole covers on crank case; (57) Governor; (58) Right hand main bearing; (59) Left hand main bearing.

Fig. 3 shows (60) Balance fuel throttling valve; (61) Port connection to (18) Fig. 1; (62) Right hand fuel piston valve; 63) Right hand air piston valve—admission for left hand air pump; (64) Fuel ports controlled by valve (62); (65) Air ports controlled by valve (63); (66) Stem connecting (62) to (63); (67) Chest in connection with supply of fuel; (68) Chest connecting to atmosphere, through sub-base; (69) Port in connection with (19) of the right hand cylinder and (20) of the left hand air pump; (71) Igniter plug; (72) Spiral gear on crank shaft in mesh with (73) on shaft (36); (74) Spiral gear in mesh with (72) for driving governor

spindle (75); (76) Ball bearing for carrying governor; (77) Sliding collar; (78) Arm connecting (77) with shaft (79); (80) Link connecting balls (81) with slide (77); (82) Arm connecting (32) with valve stem (83).

Fig. 5 shows (85) (86) (87) (88) Rods connecting cranks (25) (26) with wipers (89) (91) (92) (92); (90) (90) (90) (90) Valve lifters mover by wipers.

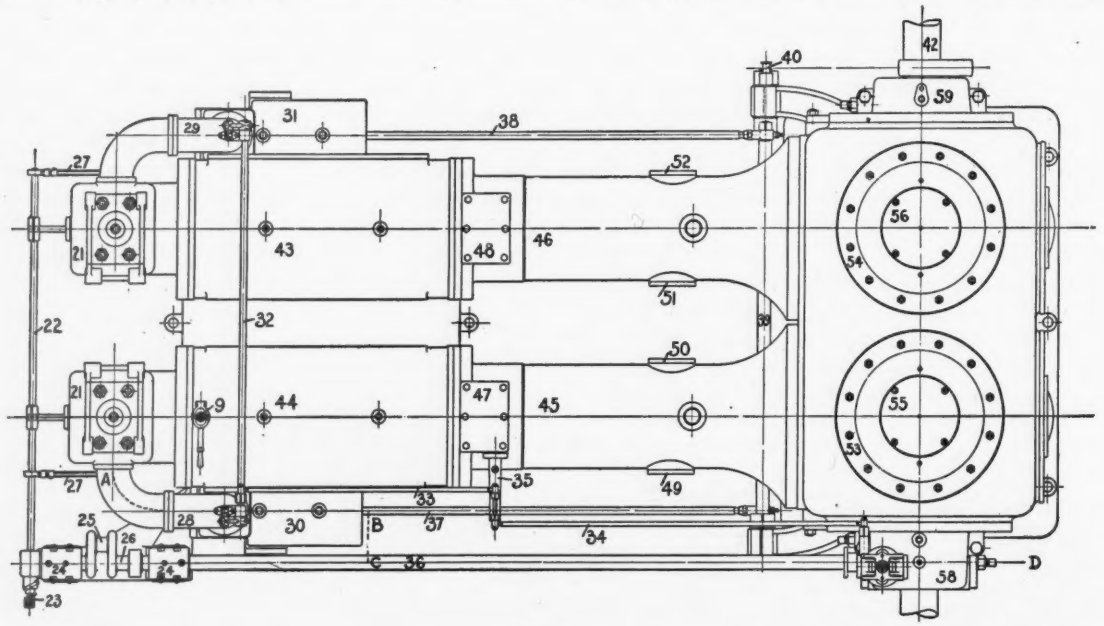


Fig. 2.

In the operation of the engine, the piston in crosshead barrel (46) Fig. 2 furnishes air at a pressure of about 8 lbs. per square inch for scavenging combustion chamber (1) Fig. 1, and piston in crosshead barrel (45) Fig. 2 compresses air at the same pressure for scavenging combustion chamber in cylinder (43) Fig. 2. Assuming Fig. 1 to be a section through the right hand engine, and piston (2) just uncovering ports (14), then compressed air furnished by air pump in barrel (46) Fig. 2 enters the combustion chamber (1) through valve (11) and port (19), forcing out the spent gases. A section through the combustion chamber at A A is circular and the conical form of the combustion chamber assists in spreading the scavenging charge evenly behind the spent charge. Somewhat later, valve (10) opens, admitting into the cylinder a charge of explosive mixture which has been compressed in chamber (3) in front of piston (2). It is thus seen that each motor piston compresses its own explosive mixture but receives its compressed air for scavenging from the opposite engine. Since valves (10) and (11) are independently driven, the relative timing of the admission of the scavenging air and the mixture is under perfect control.

When piston (2) has covered ports (14) on the return stroke the compression begins in the motor cylinder, providing valve (10) has closed; this feature being discussed later.

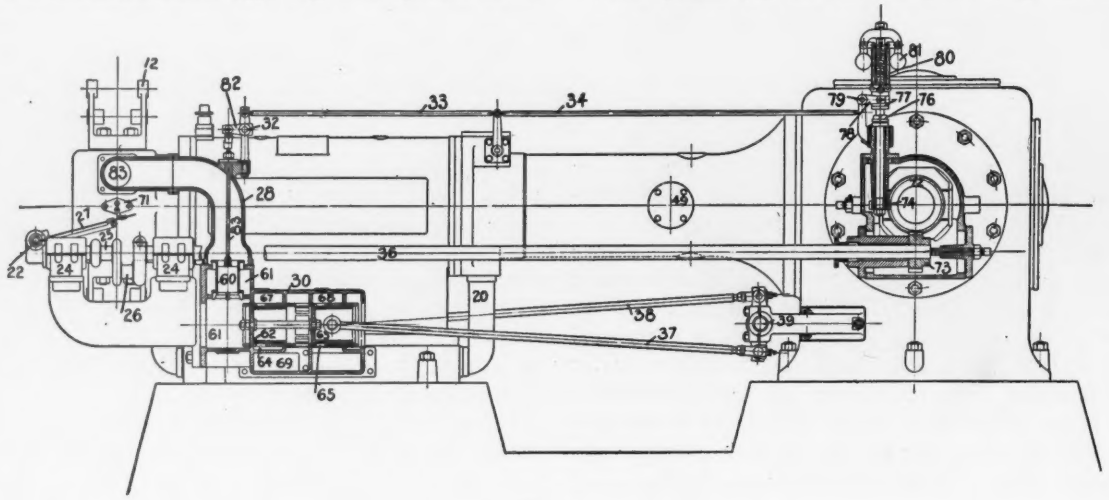


Fig. 3.

The compression being complete, the charge is fired in the usual way, firing occurring alternately in the two motor cylinders.

Pump Valves.—Fig. 3 is a section through piston valve

body (30) of the right hand engine wherein are the two balanced piston valves (62) for admitting a mixture to gas pump in cylinder (44) Fig. 2, and (63) for admitting a charge of air into port (69) which is in connection with air pump in barrel (46) Fig. 2.

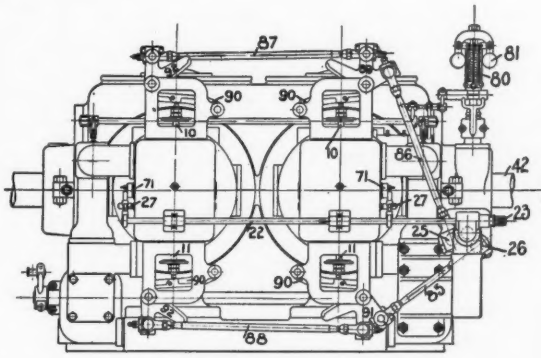


Fig. 5.

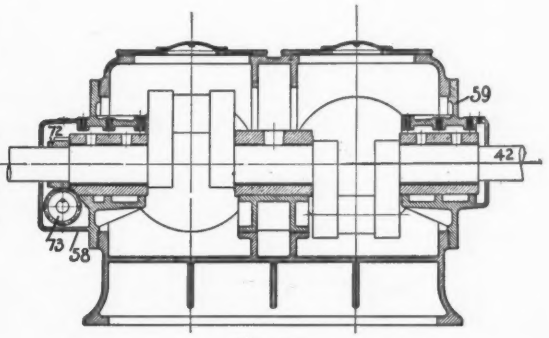


Fig. 4.

Chamber (68) communicates with the atmosphere through the sub-base of the engine. Valves (62) and (63) serve only as admission valves to their respective pumps. The pumps discharge their contents through poppet valves (10) and (11) Fig. 1, as previously described.

Speed Control.—A valuable characteristic of this engine is that so much sought for by all intelligent gas engine designers, namely, constant compression and constant mixture at all loads, combined with quick and certain response to sudden change of load.

The quantity of air passing through the air pumps is constant at all loads but the amount of air and gas handled by the fuel pumps varies according to the load carried.

In some two-cycle engines, a governor controlled throttling valve regulates the amount of fuel admitted into the fuel pump. For example, the governor might be arranged to throttle the supply to chamber (67) Fig. 3. In this case, a sudden drop from full load to no load would find a full charge of fuel that would have to be consumed before responding to the change in load. In such an engine the work done in the fuel pumps would vary with change in load but the response to the change would be slow.

Secondly, a throttling valve might be located at (83) to control the amount of mixture passing from the fuel pump to the combustion chamber. In this case a response to sudden change in load would be quick but the fuel pump would do equal work at all loads and thereby diminish the efficiency of the engine at low loads.

The system devised and used on this engine accurately combines the good qualities of the two preceding systems and eliminates their defects as follows:

When piston valve (62) Fig. 3 uncovers ports (64), the fuel is sucked into chamber (61) and from there through the

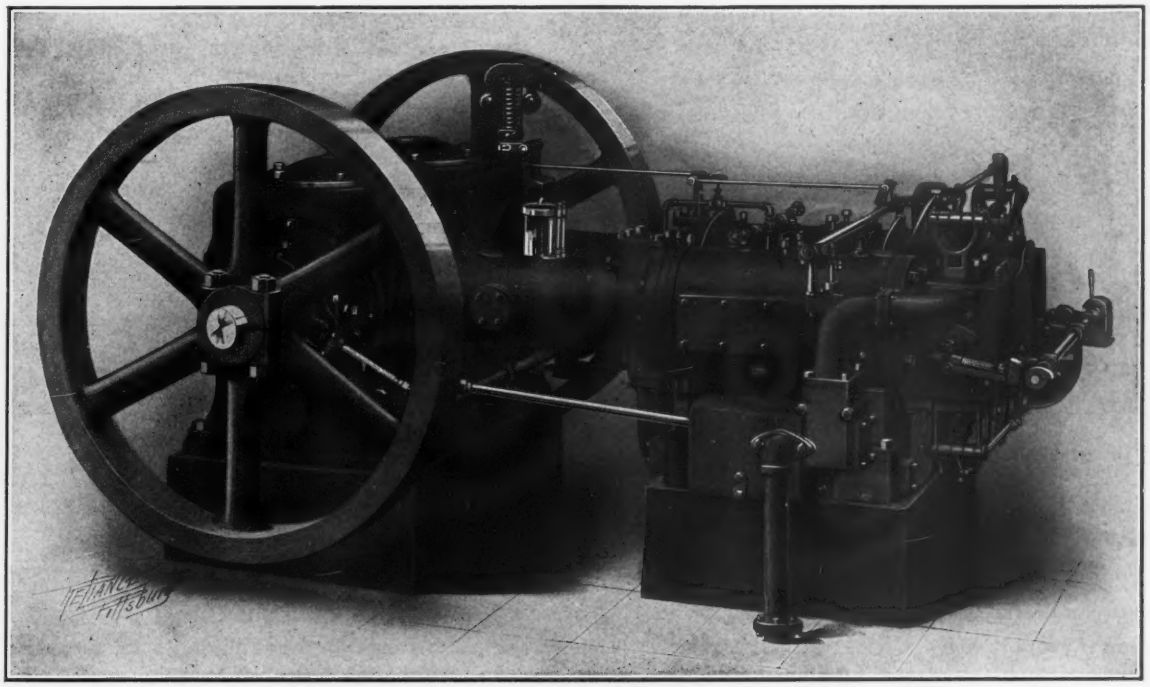


Fig. 6.—Side View of the Buckeye Gas Engine

balanced throttle valve (60) into chamber (61) which connects with chamber (18) Fig. 1, the latter being, as previously stated, part of the compression chamber of the fuel pump (3) Fig. 1. The amount of fuel passing through valve (60) depends on its position, this being directly controlled by the governor through rod (83) shaft (32) rods (33) (34), etc.

When the compressed fuel flows from pump cylinder (3) Fig. 1 to (83) Fig. 3 and the combustion chamber, it must return through valve (60), or retrace through the same way it entered. Thus, clearly, valve (60) Fig. 3 controls the amount of fuel entering the gas pump as well as the amount flowing from the gas pump to the combustion chamber. This combination of the fuel piston valve (62) and the throttling valve (60) results in an economy of pump work and quickness of action which cannot be excelled by any other method whatever.

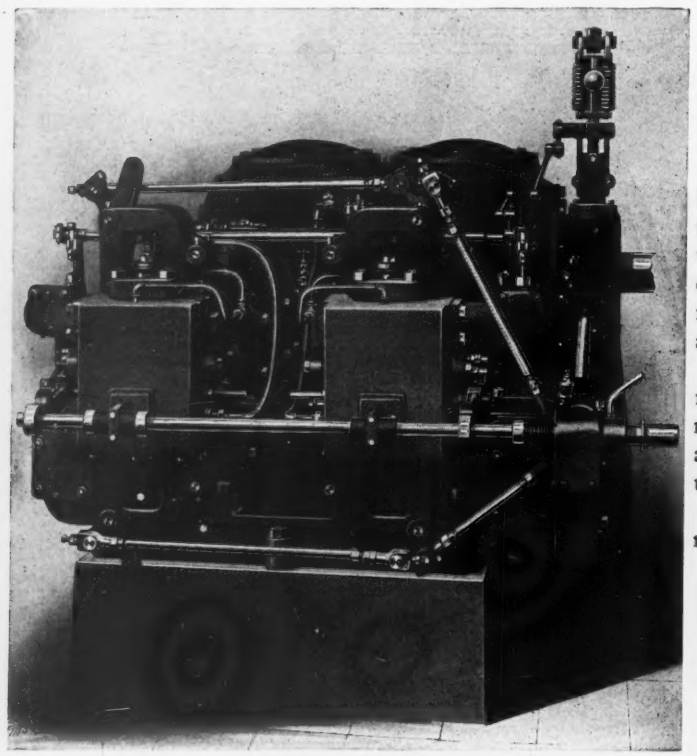


Fig. 7.—End View of Buckeye Gas Engine showing Valve Gear

The cards on Figs. 8 to 12 were taken from a 9 x 12 engine running on natural gas and on this engine, which was used for experimental purposes, no less than ten thousand were taken in about a year's time.

Igniters.—There are two sets of igniters in each combustion chamber but only one is shown. Shaft (22), Fig. 2, which operates the igniters, is driven by lay shaft (36), Fig. 2, through a pair of spiral gears, one of which is keyed to shaft (36), the other is splined to shaft (32). (23) is an adjuster for shifting the splined gear on shaft (22), thus advancing or retarding time of ignition of all igniters.

Jump Spark.—The engines are also provided with jump spark ignition apparatus. The change from one system to the other can be made in a few minutes' time.

Starting.—(9) Fig. 1 shows a balanced air valve operated by hand for admitting compressed air for starting. This may also be operated automatically from the lay shaft when desired.

Main Admission Valves.—The valves (10) (11) Fig. 1, together with cages (12), as well as the corresponding set on the other cylinder, are in exact duplicate and interchangeable. Only relatively cold gases pass through these valves. They are therefore assured of long life.

Fuel Pumps.—The temperature of the ingoing gases in all internal combustion motors should be low. Referring to fuel pump cylinder (3) Fig. 1, the water in jackets (16) and (41)

CYL.	DIA.	9"
	STROKE	12"
GAS P.		
AIR P.		
SPRING	SCALE	160
PRES.	MAX.	350
	COMP.	120
	M. E. P.	81
SPEED	R. P. M.	275
POWER	I. H. P.	
	B. H. P.	
FUEL	NAT.	GAS

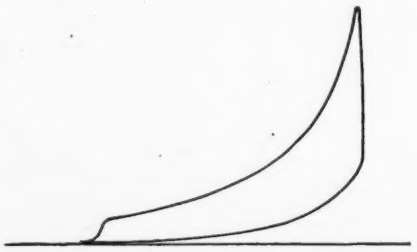


Fig. 8.

is kept as cool as possible, thus tending to keep the temperature of compression low. The head (4) Fig. 1 has on it a waterjacketed sleeve (4). This sleeve is Babbitted and bored out and on account of its considerable length, the speed of reciprocation and low pressures on each side, there is no leakage through the sleeve and it is subject to no wear whatever.

Details of Construction.—In the wrist end the connecting rod has wedge adjustment. In the crank end it is of the marine type. The main bearings contain Babbitted shells of ample area and have complete means for alignment and taking up wear.

In this type of engine, owing to the action on each connecting rod of the combined air and fuel pumps and motor

CYL.	DIA.	9"
	STROKE	12"
GAS P.		
AIR P		
SPRING	SCALE	20
PRES.	MAX.	
	COMP.	
	M. E. P.	
SPEED	R. P. M.	275
POWER	I. H. P.	
	B. H. P.	
FUEL		

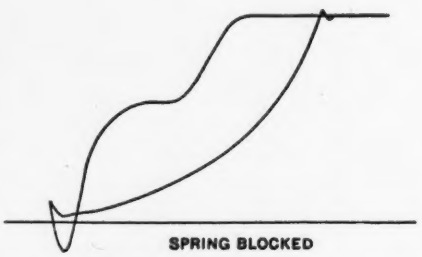


Fig. 9.

piston, it makes no material difference whether the wrist and crank-pin bearings are carefully adjusted, since the pressure is always in the same direction and therefore the engine will run quietly should even all the boxes be loose.

Crosshead pistons and main bearings are oiled by splash oiling. The spiral gears driving the lay shaft are immersed in oil. Bearings (24) (25) Fig. 2 have ring oilers.

Operation.—On account of the combined cooling action of the water jackets and the scavenging air, a high degree of compression can be carried. Another important feature in this engine is that expansion can be carried to any point what-

ever. The fuel valve can be so set that the compression may begin say at half-stroke; in this case expansion would be to twice the volume admitted. In the smaller sizes this feature

CYL.		
GAS P.		
AIR P.	DIA.	9"
	STROKE	12"
SPRING	SCALE	10
PRES.	MAX.	7.5
	COMP.	
	M. E. P.	
SPEED	R. P. M.	275
POWER	I. H. P.	
	B. H. P.	
FUEL		

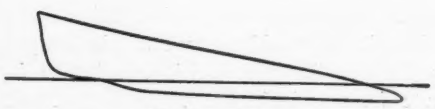
AIR PUMP

Fig. 10.

is made use of but in the larger sizes an increased thermal economy is thus available.

Suction producers require a variable amount of draft in their operation due to varying conditions of the fuel bed. Here a great advantage is obtained since the fuel pump in

CYL	DIA	
	STROKE	
GAS P.	DIA.	9"
	STROKE	12"
AIR P.		
SPRING	SCALE	10
PRES.	MAX.	8
	COMP.	
	M. E. P.	
SPEED	R. P. M.	275
POWER	I. H. P.	
	B. H. P.	
FUEL		



GAS PUMP

Fig. 11.

this engine has ample capacity to supply the engine with fuel no matter what the draft may be within large limits and a producer can in emergencies be forced beyond its rated capacity without seriously diminishing the power of the engine.

This engine is also self-cleaning, thereby making it unnecessary to take off heads and valves for cleaning. All dirt is blown out and after many months of continuous service on

CYL.		
GAS P.	DIA.	9"
	STROKE	12"
AIR P.		
SPRING	SCALE	10
PRES.	MAX.	8
	COMP.	
	M. E. P.	
SPEED	R. P. M.	275
POWER	I. H. P.	
	B. H. P.	
FUEL		

GAS PUMP

Fig. 12.

suction producer gas, the combustion chamber has been found absolutely clean. This feature is valuable when using jump spark ignition, since there will be no trouble due to fouling of ignition plugs and the consequent destroyed insulation. If so desired, a super compression can be obtained whereby the main compression begins say at 3 to 5 pounds above atmospheric pressure. This increases the capacity of the engine with a possible slight decrease in thermal economy.

An engine of about 75 horse power with cylinders 9" diameter by 12" stroke has been found by repeated tests to develop a mechanical efficiency over 85 per cent., the pump work being included as friction. The explanation for this high mechanical efficiency lies in the co-ordination of pump and motor cylinders, no loss of wire drawing through valves due to ample valve areas, the positive operation of all valves, balancing of all valves and the absence of stuffing boxes.

Tenth Annual Convention of the I. U. of S. E.

The tenth annual convention of the International Union of Steam Engineers will be held in Milwaukee, Wis., during the week beginning with September 10th. The local convention committee of which J. A. Packard is chairman, is working hard to make the convention a successful one and they have laid plans to give every delegate a regular round of pleasure during the spare moments of the convention. The ladies, who always attend the annual conventions in large numbers, will be especially cared for and a separate program has been arranged for their enjoyment.

The many natural advantages of Milwaukee make it an ideal convention city and September there is considered one of the pleasantest months in the year. Trolley rides and trips upon Lake Michigan are among the enjoyment features, while visits to the breweries and various mechanical establishments, which have made Milwaukee famous, will be among the educational features. Locals Nos. 139 and 311 have the convention in charge and they are prepared to extend a cordial greeting to all delegates.

The headquarters of the convention will be at St. Charles Hotel and West Side Turner Hall will be used for the convention hall.

New N. A. S. E. Associations in Pennsylvania.

On Saturday, July 28th, 1906, Montgomery Association No. 19, N. A. S. E., was organized by State Deputy President Richard Pape at Norristown, Pa., with over thirty charter members. The new Association is composed of some of the most energetic and experienced engineers living at Norristown, Conshohocken and Bridgeport. The officers elected and installed were: President, John T. Motz; Vice-President, Wm. G. Frederick; Secretary, John P. Leonard; Treasurer, Wm. B. Woodland; Conductor, Joseph V. Holliday; Doorkeeper, Edward F. Price; Trustees, Chas. S. Wentzel, Thos. J. Eagan and John Parkin.

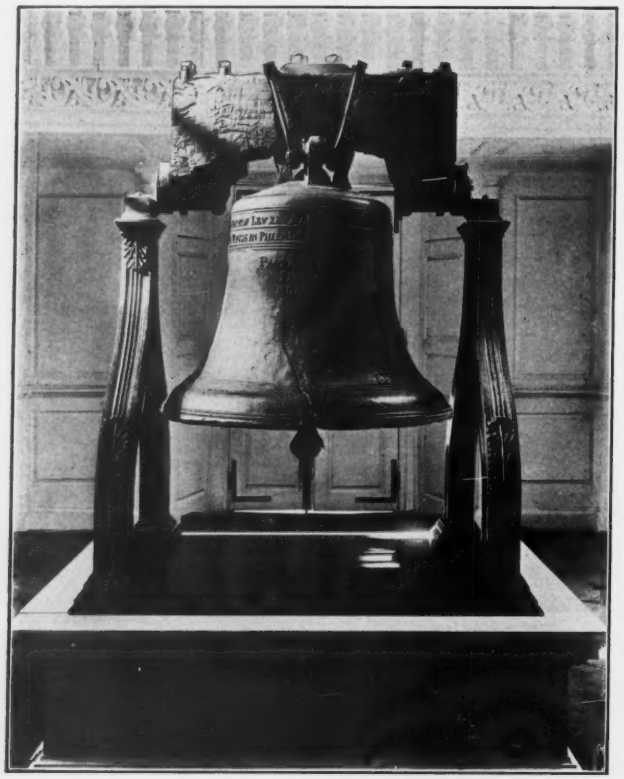
On Friday, August 17th, Du Bois Association No. 26, N. A. S. E., was organized by Chas. H. Garlick with over thirty charter members. It is said that all the members and officers are hustlers and before the end of the year it is predicted that the membership will be greatly enlarged and its educational features will be among the best.

Two men were killed and twenty injured by the explosion of a boiler at the plant of the Vincennes Paper Mill Company, on July 30th, at Vincennes, Ind. The boiler was hurled through the roof of the boiler house and landed 100 feet away. The property loss is estimated at $15,000.

PHILADELPHIA—THE N. A. S. E. CONVENTION CITY.

Plans and Arrangements for the 25th Annual Convention.

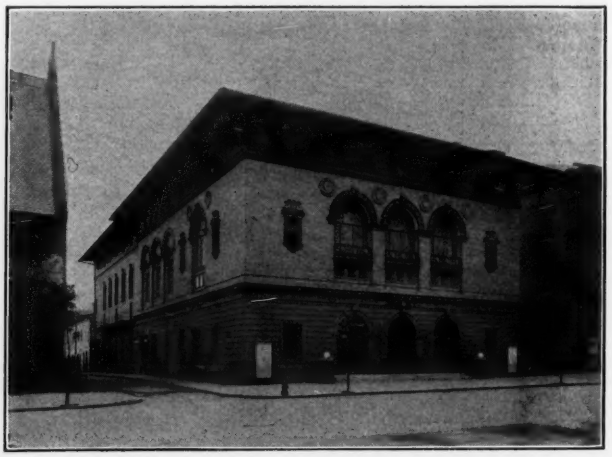
When the band of Philadelphia rooters, which attended the Louisville Convention of the National Association of Steam Engineers last year, captured the 25th annual convention for Philadelphia this year, they immediately began to lay plans for making the silver anniversary of this admirable body of engineers a banner one in the history of the organization. Not only is Philadelphia one of the largest manufacturing cities in the United States but it possesses many historical features which alone are worth going thousands of miles to see. With these things as a basis and the noted hospitality of Philadelphia engineers to supplement them, the week of September 11th to 17th should bring with it events and happenings which every engineer and visitor to the Quaker City will long remember and cherish.



The Liberty Bell—The most beloved relic in America

The city limits now include an area of 129 square miles and its population is approximately 1,500,000. There are 275,000 separate homes within its limits and since nearly each family lives under its own roof, this tendency has caused Philadelphia to be called the City of Homes. The Philadelphia City Hall, erected at a cost of about $28,000,000, with its tower measuring 548 feet from the ground to the top of William Penn's hat at the apex, is the centre of the city and is with the single exception of the House of Parliament in London, the largest public building in the world.

All of the older section, and the greater part of the present city of Philadelphia, are located on a long peninsula between the Delaware and Schuylkill Rivers. This peninsula is about 2 miles wide at Market Street, which is its narrowest point until just before the Schuylkill River flows into the Delaware River at League Island, some five miles below the City Hall. Practically all of the important shipping interests of the city are confined to the frontage on the Delaware River, which is kept open in winter from Philadelphia south by the passage of many ferry boats and other traffic, although it is frozen



Horticultural Hall—Where the Exhibits will be held

over for some distance down from Trenton. For a long time the Delaware Rivery ferry boats furnished the only means of transportation from Philadelphia to the New Jersey shore, but within the last few years an extensive bridge has been built across the river just north of Philadelphia by the Pennsylvania Railroad. This bridge connects this Company's main line with its Camden Atlantic Division, and thus furnishes an all-rail route from Philadelphia to its largest and nearest seashore resort—Atlantic City.

The Schuylkill River, which forms the western boundary of the old city, is navigable for only a short distance from its mouth, or to the Fairmount Park dam. Thence it extends

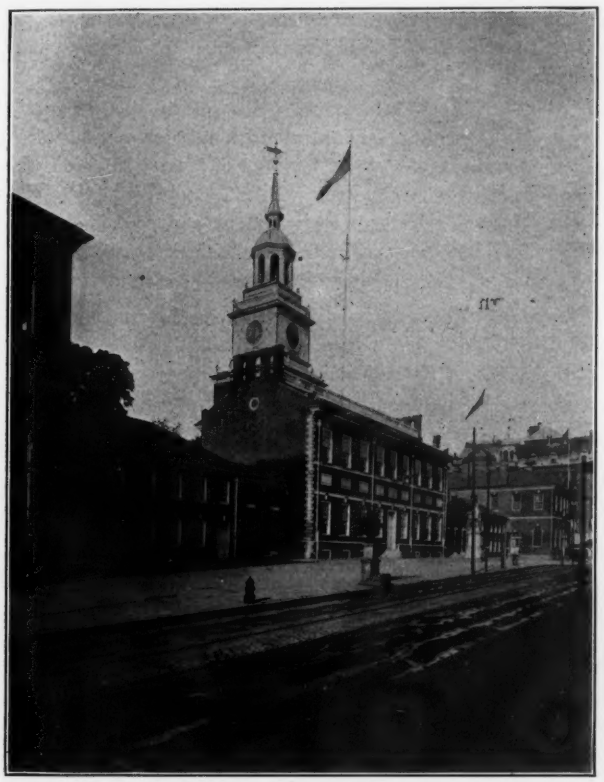
The $28,000,000 City Hall

north and west through Fairmount Park, past Manayunk, Norristown and Reading, to its source in the Blue Mountains. Crossing the Schuylkill at various points during its passage through the city of Philadelphia, are some eight or nine rail-

road and highway bridges, over which there is a constant stream of traffic.

North and northwest of Philadelphia are a great many most attractive suburban residential districts whose beauty is famous. Prominent among these suburban towns are Germantown, which lies within the city limits of Philadelphia; Ardmore, Bryn Mawr, Wayne and West Chester. Southwest of the city limits there is practically a continuous succession of residences and manufacturing establishments, extending along the river in a section a mile in width, to the Pennsylvania and Delaware State lines, 17 miles in a direct line from the Philadelphia City Hall and almost to the city of Wilmington.

The business district of Philadelphia is confined practically to a section about 1½ miles square, extending from Seventeenth Street east to Delaware River and from Callowhill Street on the north to Walnut Street on the south. The Penn-



Independence Hall—The Cradle of American Liberty

sylvania and Reading Railroads land passengers directly into this district and the ferries from New Jersey land directly at the eastern end. There are on an average of 60,000,000 passengers handled annually by the two railroads and ferries.

The business district also includes the financial district, which for the most part is located along Fourth, Fifth and Sixth Streets, between Market Street and Walnut Street; the theater and hotel district, which is centred on Market and Chestnut Streets, between Eighth and Fifteenth Streets, and also on South Broad Street, and a considerable portion of the manufacturing district, which clusters along the steam railroad tracks, extending between Callowhill and Green Streets. The other manufacturing districts of the city lie to the northeast, in Kensington and Richmond, along the Delaware River, and to the southwest of the city, along or near the Schuylkill. The finest residence district of the city is on North Broad Street and neighboring streets, near Spring Garden, although many of the older aristocratic families reside along the western part of Chestnut, Walnut and parallel streets south of Market Street. Chestnut Street and Market Street, from Eighth to Fifteenth Street, are recognized as the leading thoroughfares

Broad St. looking North. This will be the center of N. A. S E. Activity. Horticultural Hall is shown on Left and Hotel Walton and Broad St. Theatre are shown on the Right

for the largest retail stores, while Eighth Street appeals more to those shoppers who are seeking bargains.

From a historical point of view, Philadelphia, the City of Brotherly Love, was founded by William Penn in 1682. The old city was ever a hot bed of liberty loving people and was one of the storm centres of the Revolution. Within a short distance from the centre of the city at Fifth and Chestnut Streets is located Independence Hall, where the Declaration of Independence was drafted and signed and where after the war, the Constitution of the United States was framed. Until

Baldwin Locomotive Works—Where 15,000 Men turn out out Eight Locomotive each Day.

1800, it was occupied by Congress and it was here where Washington was inaugurated President for his second term and where John Adams took his oath of office as President. The most precious of America's relics—the Liberty Bell—re-

poses here in silence and is viewed by thousands of strangers yearly. Within a short distance of the birthplace of liberty is Carpenter's Hall, south of Chestnut Street between Third and Fourth, which is almost as much venerated. It was here that the Continental Congress met and from which emanated the resolutions and measures which led to the existence of the present national government. Betsy Ross's house is also close by on Arch Street near Third, and is noted as being the birthplace of the American flag. It was Betsy Ross who made the first flag of thirteen stars and thirteen stripes which was adopted as the national ensign. Throughout the city there are also various other historic places of interest which are brim full of revolutionary history.

Among the modern buildings and places representing the scientific, artistic, educational and industrial progress may be mentioned the Baldwin Locomotive Works, Cramp's Shipyards, League Island Navy Yard, United States Mint, Academy of Fine Arts, Academy of Natural Sciences, Commercial Museum, Girard College, Drexel Institute, University of Pennsylvania and Franklin Institute.

The Baldwin Locomotive Works, situated at Broad and Spring Garden Streets, is the largest industrial plant of its kind in the world. It turns out, every working day, from

Richard Pape. Chairman of the N. A. S. E. Convention Committe

seven to ten finished locomotives. Cramp's Shipyards is a place of great interest as there are building a number of ocean steamships and a number of Uncle Sam's warships. The United States Mint is located at Sixteenth and Spring Garden Streets and is the mother mint where most of the gold, silver and copper coinage is turned out. The list of inventions, discoveries and institutions that have had their birth in Philadelphia is very numerous but a few of them are the first law school in America, the first American volunteer fire department, the first mint of the United States, the first medical school and college of pharmacy in America, the first paper mill, the first piano-forte, the first city waterworks, the old Ironsides, the first locomotive erected in the world, the first daguerreotype or photograph of the human face, the first daily newspaper, the first railroad track, the first experiments for moving water vessels by steam and the first demonstration of the theory that lightning is electricity.

PLANS FOR THE CONVENTION.

The convention committee have been at work faithfully throughout the past eight months and have arranged the program as follows:

Monday, 10th, 9.00 a. m. to 7.00 p. m.—Reception of delegates and visitors at the various railroad depots, and escorting them to the hotel and registering headquarters. *8.00 p. m.*—Reception to the national officers and delegates at the Hotel Walton. Music by orchestra.

Tuesday, 11th, 10.00 a. m.—Introductory convention exercises in South Broad Street Theatre. Addresses of welcome by Mayor Weaver and prominent officials and citizens. Responses on behalf of the N. A. S. E. by National President R. D. Tomlinson and National Vice-President T. N. Kelsey, and others. *12.00 m.*—Formal opening of the convention, followed by a recess. *2.00 p. m.*—Business session of the convention. *3.30 p. m.*—Opening of the exhibit of the National Association of Supplymen, in Horticultural Hall, by National Vice-President T. N. Kelsey. *7.00 p. m.*—Annual meeting of the Life and Accident Department, 10th floor, Hotel Walton. *7.00 to 10.00 p. m.*—Exhibition Hall open to delegates, ladies and visitors.

Wednesday, 12th, 9.00 a. m.—Session of the convention. *9.30 a. m.*—Opening session of national convention of the Ladies' Auxiliary. *1.45 p. m.*—Special cars at Broad and Locust Streets for Arch Street wharf. *2.00 p. m.*—Steamboat ride on Delaware River. Refreshments on boat. Music by band. *6.00 p. m.*—Return by boat to Arch Street wharf, where special cars will take party to hotel headquarters.

Thursday, 13th, 9.00 a. m.—Session of the convention, and session of Ladies' Auxiliary. *10.00 a. m.*—Ladies' local committee will escort visiting ladies through the department stores. *2.00 p. m.*—Business session of the convention. *2.00 p. m.*—Tallyho ride for ladies from Broad and Locust Streets to and through Fairmount Park, with stop at Belmont Mansion for light refreshments; returning to hotel at 6.00 p. m. *8.00 p. m.*—Theatre party for delegates and guests, at Eleventh Street Opera House.

Friday, 14th, 9.00 a. m.—Session of the convention. Session of Ladies' Auxiliary. *2.00 p. m.*—Session of convention. *2.30 p. m.*—Ladies' local committee will escort visiting ladies through Independence Hall, Carpenter's Hall, and other points of interest. *8.00 p. m.*—Public installation of newly-elected national officers, and Grand Ball.

Saturday, 15th.—Arrangements have been completed with railway company for reduced fare for all who wish to visit Atlantic City.

Monday, 17th.—Business meeting of the National officers.

No better part of the city could have been selected for the convention. Hotel Walton, the headquarters, Horticultural Hall, the exhibition hall for engineers' supplies and the South Broad Street Theatre the meeting hall are all adjoining so that Broad and Locust Streets, where the buildings are situated will be the beehive of engineering good-fellowship during the convention week. Hotel Windsor, located at 1225 Filbert Street, will be the headquarters annex.

The general committee having the convention in charge is as follows: Richard Pape, Chairman; G. F. Duemler, Enoch Carless, Ernest C. Fox, Eb. Carless, Jas. S. Gillespie, E. Caldwell, Richard E. Calvert, Chas. Rostron, V. L. Rupp, Al. Winthers, Chas. Coburn, John T. Gaskill, John A. Buggy and Jas. D. Rostron.

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

Rollins Automatic Four Valve Engines are attractively shown in a handsome new catalogue just issued by The Rollins Engine Co., Nashua, N. H.

A new catalogue devoted to their patent interchangeable exhaust fans, dry kiln systems, dust collecting systems, heating and ventilating systems, mechanical draft systems, automatic turnace feeders, etc., has been issued by the Hartford Blower Co., Hartford Conn. Write for copy.

The National Pipe Bending Co., of New Haven, Conn., are erecting a large new foundry building in connection with their present plant.

A new catalogue issued by the builders of Terry Steam Turbines describes these turbines at length and shows several excellent illustrations of direct-connected units. It also discusses the advantages of steam turbines in general over reciprocating engines. A copy will be mailed to any reader who is interested in turbines. Address Terry Steam Turbine Co., Hartford, Conn.

The Keystone Lubricating Co., Department of Philadelphia, have issued an extremely interesting folder entitled, "Comparative Weight, Volume and Price of Lubricants." It discusses the weight, volume and price of both grease and oil and draws some decidedly interesting comparisons which many engineers will appreciate. A copy of this folder will be mailed to any engineer or user of lubricants upon request.

Wilfong & Wiltbank, 420 Mutual Life Building, Philadelphia, who have been selling Cope's Boiler Feed Regulator and other boiler room specialties, have been succeeded by American Boiler Economy Co., same address, with Mr. Chas. G. Wilfong as Vice-President and General Manager, and Mr. Henry C. Wiltbank, Secretary. The capital of the Company has been increased and its scope and facilities extended. The Company has bought the Cope's Regulator patent. The Company advise us that the sales of Cope's Regulators have already been large and the indications are for continued increase as the Regulator and also their House Tank and Elevator Tank Regulators are giving splendid satisfaction. Their new catalogue will be mailed upon request.

Ebonite sheet packing which is new to many of our readers is described in the advertising pages of this issue. A piece of Ebonite will be mailed as a sample to any reader who wants to get acquainted with it. Address Quaker City Rubber Co., Philadelphia, and ask for their new packing catalogue.

The Perfection Flue Blower is a new device which blows several tubes at the same time and from the back of the boiler instead of the front without opening the front doors and admitting cold drafts. Another advantage in blowing from the back is that it causes an induced draft. It is claimed that the flues can be cleaned in about two minutes and practically without any labor. This device is made by Perfection Grate Co., Beese Building, Springfield, Mass. A circular describing it will be sent upon request.

The Newton Machine Tool Co., of Philadelphia, have elected new officers as follows: Harry W. Champion, President; William M. Graham, Treasurer; Ellis J. Hannum, Secretary. The election of new officers is occasioned by the death of Mr. Charles C. Newton, founder and president of the Company, with whom the above-named officers have been closely associated in executive positions for many years.

Since the recent fly-wheel accident which wrecked one of the large engines and practically demolished the power house at Penrose Ferry, Philadelphia, the rebuilt plant has been equipped with a Locke engine stop.

The Quaker City Rubber Co., of Philadelphia, who are the original and only makers of the now celebrated P. P. P. rod packing tell us that P. P. P. weighs from 20 to 40 per cent. less than solid packings, which is an advantage when buying by the pound. They have issued a new packing catalogue which is good enough to write for, if you have not already received one.

The James Leffel & Co., Springfield, Ohio, have issued a very handsome and complete new 52-page catalogue, illustrating and describing their line of steam engines and boilers. The details of construction are plainly shown and fully explained, and the catalogue is one that should be in the hands of any prospective purchaser.

The Cherry Chemical Co., 10 North 19th St., Philadelphia, manufacturers of Red Seal Boiler Compound, report that their business has increased remarkably during the first six months of 1906. They attribute it to the merit of their goods. We are informed that all compounds manufactured by this Company are done on analytical basis. Send them two ounces of scale by mail, or one gallon of water by express, prepaid, and they will make an analysis free of charge.

The Burrows Mfg. Co., 73 Warren St., New York City, have issued a catalogue which they want to send to engineers and steam users who are interested in steam traps, damper regulators, or boiler feed regulators. A postal card will bring you a copy, and it's worth it.

The White Star Filtering System is cleverly described in booklet "F" issued by Pittsburg Gauge and Supply Co., Pittsburg, Pa. If your filtering system is imperfect it will pay to send for a copy. The White Star system is for the smallest plants as well as the largest.

The A. W. Harris Oil Co., 320 S. Water St., Providence, R. I., are makers of specific oils for specific purposes. Many years ago this firm began to study the science of lubrication along these lines, and after years of experimenting and many costly tests they have developed what is perhaps the most perfect line of lubricating oils to be found anywhere in the world. Their catalogue is well worth studying.

H. B. Underwood & Co., 1025 Hamilton St., Philadelphia, have gotten out a clever Key Ring as a souvenir for the N. A. S. E. Convention. Engineers who do not attend the Convention can procure one by sending a two-cent postage stamp.

The General Engineering Co., 764 South Swanson St., Philadelphia, have contributed their share toward the relief of humanity from the heat and the ice trust in Philadelphia and vicinity during the past few weeks; having installed ice machines at the following places: Abbott's Dairies, Atlantic City; Hotel Islesworth, Atlantic City; Belle Meade Sweets Makers, Trenton, N. J.; F. A. Wills, 1204 Montgomery Ave., Phila.; McEwen Milk Co., 1515 North 26th St., Phila.; T. G. Hufnal, 1330 South Juniper St., Phila.; H. Dolfinger, 1534 South 16th St., Phila.; G. F. Benckert, Sixth and Jackson Sts., Phila.; L. Balzereit, Franklin and Parrish Sts., Phila.; J. H. Schurr, Douglasville, Pa. They have also made and installed the brine tanks at all of these places and are also making and installing the brine tanks for the Breyer Ice Cream Co., Ninth and Cumberland Sts., Phila.

Wanted Salesmen traveling among engineers to sell the France Metallic and Fibrous Packings. Good inducements on unoccupied territory, Address
FRANCE PACKING Co., Tacony, Phila., Pa.

PATENTS Watson E. Coleman, Patent Attorney, Washington, D. C. Advice free. Terms low. Highest ref.

PATENTS Procured ISEDORE S. PRENNER, E.E. Attorney-at-Law, Solicitor of Patents, Consulting Engineer, Law, Patent and Engineering Cases.
Room 1108 Betz Building, Philadelphia.

PATENTS PROMPTLY SECURED. Highest references from prominent manufacturers. Write for Inventors' Hand-Book, SHEPHERD & PARKER, 186 Deitz Building, Washington, D. C.

WANTED—Agents in every state to sell a new (paste) packing as a side line. Used anywhere in place of sheet packing at one-fourth the cost. Liberal commission. WOODARD PASTE PACKING CO., Owosso, Mich.

WANTED—To buy a second-hand Valve Model cheap, will pay spot cash. Give particulars and full description. H. C. H., care The Practical Engineer, 46 N. 12th St., Philadelphia.

FOR SALE—A slightly used engineering library, bound three-quarters leather. Ten volumes. Cost $50.00. Will sell for $15.00. Address BOX 5, The Practical Engineer.

FOR SALE—Cyclopedia of Engineering. Four volumes, bound in half morocco. Slightly used. Cost $18.00. Will sell for $4.00. Address BOX 3, The Practical Engineer.

The American School of Correspondence want to send their 200-page handbook describing their course in engineering work to readers of THE PRACTICAL ENGINEER who clip out their advertisement on page 80.

A new 36-page catalogue, 7 x 10 inches, has been issued by The Sims Co., Twentieth St., Erie, Pa., describing the Sims Feed-Water Heater, both open and closed types and giving sizes, capacities, prices and other information useful to those contemplating the installation of a new heater. Copies mailed upon request.

The Collins Regulator Co., Conshohocken, Pa., manufacturers of Damper Regulators advise us that they are rushed with orders for their new regulators. This concern make a specialty of taking old regulators of other makes in part payment for new ones.

The annual picnic given each year by The Lunkenheimer Company to its employees was held at Woodsdale Island, thirty miles from Cincinnati, on July 28th. At these picnics the Company furnishes all the amusements, refreshments and transportation to the employees and their families. This year there were two special trains of ten cars each, about 2,500 in all. There were two bands of music in attendance and a troupe of professional entertainers. There were games and amusements of all sorts and all present spent a jolly day.

The continuous service foot valve is described in detail in a circular issued by The Newman Mfg. Co., 26 Cortlandt St., New York. This foot valve placed on a suction pipe taking water for boiler feed or other purposes from a stream or pond will keep out leaves, sticks, fish, pebbles, etc. It can be operated continuously without interruption, being so constructed that it may be cleaned while in operation without difficulty.

A fine new catalogue just received from The Bruce-Merriam-Abbott Co., Cleveland, Ohio, describes the construction and operation of their gas and gasolene engines very comprehensively. The illustrations are unusually good and are of the right character, showing both sectional and exterior views, and also featuring the parts. These engines are built mostly in the larger sizes for electric lighting, pumping and general power purposes. Those who are interested in gas engines should procure one of the new catalogues.

A subscriber is very anxious to be informed of the present addresses of the following engineers who, when last heard from, were at the addresses given: Wm. F. Fletcher, Holloway, O.; Steven Everett, Whitmire, S. C.; Wm. Bayman, Lancaster, O.; Dale Cunningham, Seattle, Wash., and C. E. Parry, Renfrew, Ont., Canada. Please address Anxious Subscriber, care of THE PRACTICAL ENGINEER, 46 N. Twelfth St., Philadelphia.

Mr. Thos. G. Keogh, 434 Park Row Bldg., New York, who just recently embarked in business has been awarded a large contract for gauge equipment, indicators and kindred goods by the Isthmian Canal Commission. Mr. Keogh has also closed a contract for a pumping and water distributing plant for the House of Divine Providence, at Ridgewood, N. J.

Tauril is the name of a new high-pressure sheet packing which is quite different in construction and appearance from other sheet packings, and which is said to be marvelously strong and durable. It is made by the Garlock Packing Co., Palmyra, N. J. A sample will be sent to any reader of THE PRACTICAL ENGINEER.

What you want is "Hot soft water for your boilers." That's what the Harrison Safety Boiler Works say in their advertisement on page 75 of this issue, and it would be a good thing for some engineers to repeat over and over until they remember it, not to forget.

Engineers in Tin Plate Mills, Galvanizing Works, Oil Refineries, Paper Mills, Tanneries, and all places where acids of any kind have a tendency to injure valves will be interested in a new anti-acid valve which the Homestead Valve Co., of Pittsburg, have placed on the market. These valves have been in use now for more than three years and have stood the most severe tests under extremely hard conditions. Further information may be had by writing the Company.

Renewed Incandescent Lamps mean a large saving in cost. The Boston Incandescent Lamp Co., whose advertisement appears on page 52. offer a special souvenir with orders placed during September.

The C. H. Wheeler Manufacturing Co., manufacturers of Condensers, Pumps, Heaters, Water-cooling apparatus, etc., located at 18th St. and Lehigh Ave., Philadelphia, have taken floor space in Section R, Philadelphia Bourse, Machinery Hall, where a permanent exhibit and branch office will be maintained under the care of Mr. F. S. Broadhurst.

About the best lot of letters from pleased customers that has come to our notice are in the catalogue of the Buckeye Boiler Skimmer Co., Colburn Ave., Toledo, O. The catalogue also describes the action of the Buckeye Skimmer in detail and shows its application to various types of boilers. A postal card will get a copy for you.

Atlas Engine Works, Indianapolis, Ind., have sent us a copy of their new Bulletin No. 131 on the Atlas Single Valve Engines which is instructively written and attractively illustrated. All parts are shown separately in detail, and there are several half-tone illustrations of complete units of different classes together with specification data for all sizes. Indeed this is one of the most thorough and comprehensive engine bulletins that we have seen. Readers who are interested in the selection of an engine will do well to write for a copy.

A. W. Chesterton & Co., 64 India St., Boston, Mass., inform us that their sales of "Combination" piston packing, and "Rubberbestos"

GRAPHO
SOMETHING NEW
A new preparation for enriching oils.
Will suspend in oil.
No more Hot Journals.
Engineers who have tried same claim it to be the best yet.
SEND FOR SAMPLE
A trial will convince you
AGENTS WANTED
GRAPHO MFG. CO.
Cor. Frank and Commercial Sts.
ROCHESTER, N. Y.

Sheet are increasing enormously as engineers become better acquainted with the respective merits of them. Samples and prices will be furnished any reader of THE PRACTICAL ENGINEER upon request. Chesterton's combination Scraper and Brush for cleaning boiler flues has also become a general favorite with engineers.

The new catalogue No. 10 of the Foster Engineering Company, describes clearly a few of the "Foster" valve specialties, such as their pressure regulators, pump governors, float valve, back pressure valve, free exhaust valve, fan engine regulator and automatic emergency non-return stop valve. Their pressure regulators maintain a constant pressure in the delivery pipe, where it is desired to obtain a uniform low pressure of steam, water, gas or air, regardless of any variations that may occur in the source of supply. The Foster pump governor is controlled solely by the discharge pressure from the pump. Their float valves are designed to be quick and sensitive and may be located at any desired point on the supply pipe of an open tank service, or on the steam supply pipe to pump delivering water to tank, or of a pump returning water of condensation from an inclosed tank to the boilers.

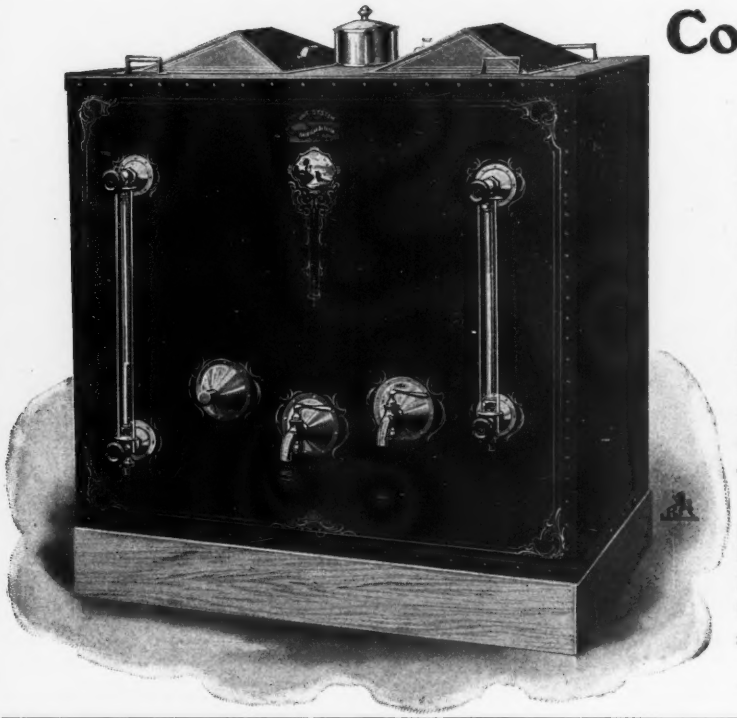
The Foster relief or free exhaust valve is used extensively in condensing engines. It gives instant relief to the exhaust in case of failure of the condenser and a loss of vacuum. Foster blower engine valves are used for governing the speed of forced or induced draft fans by the pressure in the boiler and the Foster automatic non-return stop valve provides an absolute safeguard against disaster in a battery where two or more boilers are connected to a single header.

Every engineer who needs any valve specialties should write at once to Foster Engineering Co., Newark, N. J., and get Catalogue No. 10.

The Buckeye Boiler Skimmer Co., of Toledo, Ohio, have recently installed a number of their automatic floating skimmers in Philadelphia plants, all of which, we understand, are producing splendid results.

Induced draft apparatus for boilers at the following plants is being installed by the B. F. Sturtevant Co., Boston, Mass.: St. Paul Gas Light Co., St. Paul, Minn.; Municipal Electric Plant, Burlington, Vt.; Firth-Stirling Steel Co., Giesboro Manor Siding, D. C.; Union Abattoir Co., Baltimore, Md.; Jerseyville Illuminating Co., Jerseyville, Ill.

One "Unit Type" Oil Filter Is a Complete System



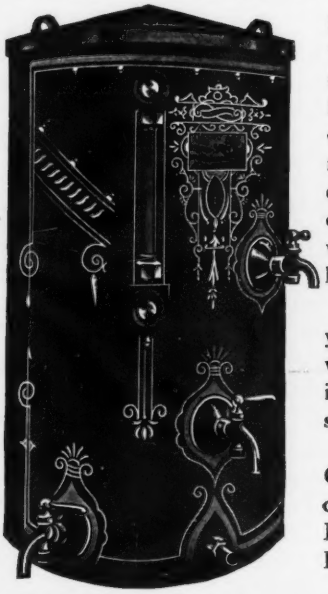
It isn't necessary to have an elaborate filtering system. One "Unit" works just as efficiently as a number of them. When the plant increases, additional "Units" can be installed and connected with those in operation.

"Unit" Filter has filtering capacity of from 175 to 225 gallons every 24 hours and is so constructed that any kind of filtering material may be used. It is guaranteed to purify the thinnest as well as the heaviest grade of lubricating oil—as cylinder, crank case, lard oil, etc.

United States Steel Corp, recently purchased four; Calumet & Helca Mining Co., seven; New Orleans Ry & Light Co., two: Phila. Rapid Tn Co., 16; John D. Rockefeller two; also the Penn Steel Co.

Of course, there is a reason for this.

The Cross Oil Filter



is and investment that will surely pay large dividends. It will save from 50 to 75 per cent. of the oil used, by removing dirt and grit enabling you to use the oil over and over again without affecting its lubricating qualities.

We will send it to you on 30 days' trial, with the understanding if it doesn't prove itself, send it back.

Send for 48 page Catalogue describing our line of Oil Filters, Exhaust Heads and the Bent Ventilator.

Only Dry Steam Escapes from Pipes Equipped with Burt Exhaust Head

It prevents injury to walls and roofs caused by dripping water and oil.

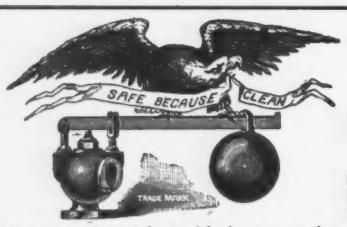
It's the strongest, safest and most reliable head made.

The Burt Mfg. Co. Largest Manufacturers of Oil Filters in the World. 204 Main Street, AKRON, OHIO, U. S. A.

Carried in stock by Shelby & Co., 66 Leonard Street, London, E. C., England, Sole Agents for Great Britian.

ALPHABETICAL INDEX TO ADVERTISERS

American Boiler Economy Co..... 62
American Injector Co..... 80
American School of Correspondence. 80
American Water Softener Co..... 62
Ashton Valve Co..... 61
Audel, Theo., & Co..... 67
Baum, The Separator & Machine Co. 76
Birdsboro Steel Foundry and Machine Co. 83
Borgner, Cyrus 47
Boston Incandescent Lamp Co..... 50
Brandt, Randolph 53
Bridgman Bros. Co..... 57
Buckeye Boiler Skimmer Co., The... 80
Buckeye Engine Co.....87-88
Burt, The, Mfg. Co..... 45
Carr, Joseph 56
Cherry Chemical Company, The..... 52
Chesterton, A. W., & Co...Second Cover
Cleveland Rubber Works..... 73
Climax Lubricator Co..... 70
Cook's, Adam, Sons..... 56
Davis, I. B., & Son..... 77
Davidson, M. T..... 88
Detroit & Buffalo Steamboat Co..... 44
Dearborn Drug and Chemical Works 59
Detroit Lubricator Co..... 70
Direct Separator Co..... 79
Dixon, Joseph, Crucible Co..... 52
Dunham, Co., C. A..... 61
Foster Engineering Co..... 69
France Packing Co..... 60
Frederick Goetze 53
Frick Company 88
Gandy Belting Co..... 52
Garlock Packing Co..... 72
General Engineering Co.....57-79
General Specialty Co..... 54
Goubert Mfg. Co..... 79
Gould Packing Co..... 56
Grapho Mfg. Co..... 44
Green, Tweed & Co..... 69
Harris Oil Co., A. W..... 67
Hartford Engine Works..... 88
Harrison Safety Boiler Works..... 75
Holmes Metallic Packing Co..... 60
Homestead Valve Mfg. Co..... 86
Huyette, Paul B., Company..... 77
Indicator Instruction Co..... 69
Industrial Engineering Co..... 83
International Correspondence Schools 83
Jenkins Bros.....Fourth Cover
Kelly, Benj. F., & Son..... 76
Keystone Lubricating Co...1, 2, 3, 4, 5, 6
Keystone Elevator Inspection and Repair Co. 83
Kieley & Mueller..... 52
Kutztown, The, Foundry and Machine Co. 76
Lagonda Mfg. Co., The..... 55
Lindstrom, John T..... 61
Lippincott Steam Specialty and Supply Co. 69
Livezey, John R..... 58
Lonergan, J. E., & Co..... 69
Lord, The Geo. W., Co.,
89, 90, 91, 92, 93, 94, 95, 96
Lukenheimer, The, Company..... 87
Main Belting Co..... 52
McAdoo, Thos. 77
McLeod & Henry Co..... 71
Merrill, W. B., & Co..... 60
Milligan, William 52
National Pipe Bending Co..... 77
Newman Mfg. Co..... 47
New England Roller Grate Co..... 68
New Jersey Asbestos Co..... 56
New York Belting and Packing Co.. 7
Nonpareil Cork Mfg. Co..... 58
Ohio Blower Co..... 74
Ohio Injector Co..... 81
Patterson, F. L., & Co..... 76
Patterson Mfg. Co..... 62
Penberthy Injector Co..... 81
Peerless, The, Rubber Mfg. Co..... 8
Philadelphia Grease Mfg. Co., The. 82
Philadelphia Hydraulic Works..... 56
Philadelphia Lubricator & Mfg. Co.. 70
Pittsburg Gauge and Supply Co..... 47
Powell Co., Wm..... 83
Quaker City Rubber Co.....84-85
Reilly & Fearon Co..... 57
Reeves Engine Co..... 88
Rich, J. & G..... 57
Robertson, Jas. L., & Sons..... 72
Rogers Co., H. A..... 56
Ruwell, W. F..... 57
Shackley, W. T., & Sons..... 56
Smith, W. Clifford..... 44
Smith, W. R. C., Pub'g Co..... 51
Spon & Chamberlain..... 43
Starrett, L. S., Co..... 80
Stephenson Mfg. Co..... 70
Sterling Pipe and Blower Co..... 53
Tulley, Henry C., & Co..... 57
Underwood, H. B., & Co...63, 64, 65, 66
United States Mineral Wool Co..... 56
United States Metallic Packing Co., The 60
Walsh Packing Co..... 71
Warley & Co., Thos. C..... 46
Watson & McDaniel Co..... 52
Wetzel Mechanical Stoker Co..... 69
Wheeler, C. H., Mfg. Co.,
First Cover and 78
Whitlock, The, Coil Pipe Co..... 77
Wilkinson Mfg. Co..... 68
Williams Gauge Co.....48-49
Williams Valve Co., D. T., Third Cover
Worner, O. and W. A..... 52
Wright Manufacturing Co..... 61
Zurn, O. F., Co..... 56



IT SHOULD BE IMPORTANT TO ENGINEERS AND STEAM USERS

to know that the formulas of

WARLEY'S BOILER CLEANSING COMPOUNDS

are founded on sound chemical principles, and that only the purest grades of chemicals obtainable, regardless of cost, are used in the preparation of these goods, which have now been on the market throughout the United States and Canada, and in many other foreign countries as well, for a great many years, and they are now well and favorably known to thousands of Engineers and Steam Users as Boiler Cleansing Compounds that positively remove incrustation or scale and prevent corrosion and pitting in steam boilers, without doing any injury to the boilers, or their fittings, or to any goods in course of manufacture while using the live steam from the boilers with these Compounds in use therein.

These Compounds are varied to suit the individual needs of steam users, and the grade required can be determined when we are furnished with a small piece of scale from the boiler in which the Compound is to be used, a piece weighing about two ounces will be large enough for our purpose.

Send for Blue Book "Questions and Answers for Engineers, etc.," which we will mail to any Engineer, free, who is in charge of a steam boiler, and who will give us the name and address of firm by whom employed and send us a small piece of scale from his boiler, also mention this paper. Address :—

No. 221 South Front Street **THOS. C. WARLEY & CO.** **PHILADELPHIA, PA.**

We also carry a full line of High Grade LUBRICATING OILS and GREASES. A trial order solicited.

The Continuous Service

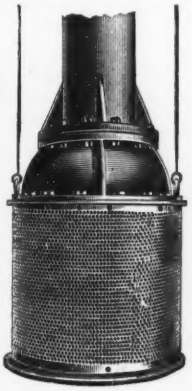
Foot Valve

Water can be taken continuously and without interruption from streams and ponds that are full of leaves, twigs, fish, sticks, paper and other refuse.

Outer Screen Drawn part way up on suction pipe

NO STOPPAGE FOR CLEANING

The outer screen is raised by ropes or chains for cleaning.



Outer Screen resting on bottom plate

When outer screen is lowered into position the knives at top and bottom scrape the outer surface of the inner screen and clean it.

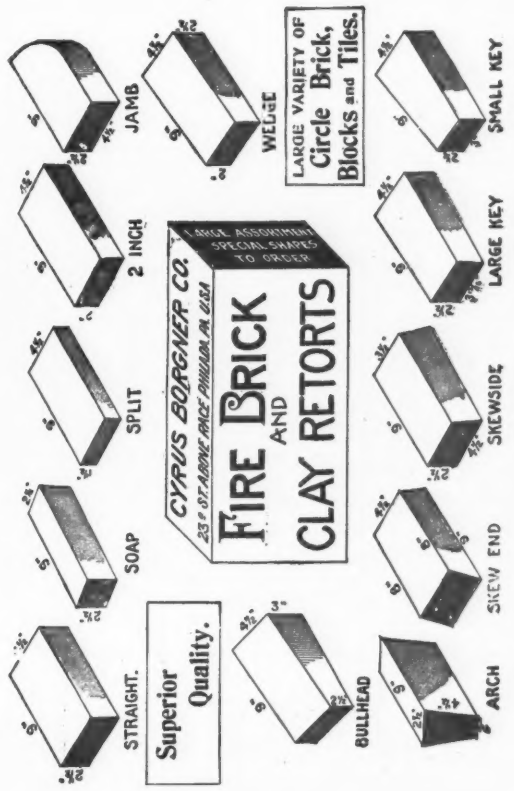
The suction pipe extends to within a few inches of the bottom plate of valve, thus permitting of successful operation in shallow water.

WRITE FOR PRICES

The

Newman Mfg. Co.

26 Cortland St., New York



Every Engineer

desires to operate his plant with the utmost practicable economy.

Every Employer

is anxious to keep the expense account just as low as possible.

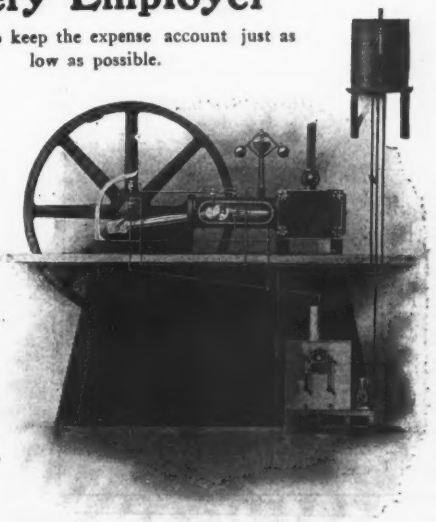
In a power plant where the

White Star Continuous Oiling System

is in use, the saving of oil is astonishing from the start and and becomes fairly astounding as the weekly items pass into the monthly totals, and the monthly totals mount into yearly aggregates showing

REDUCTIONS OF FULLY ONE-HALF

The savings begin with the first minute the system is in operation. We have been collecting facts and figures on the subject which we will be pleased to send, together with booklet "F" which illustrates and describes our method of perfect and economical lubrication of engine bearings. Send for it.



Pittsburgh Gage & Supply Co., Pittsburgh, Penna.

Williams Steam Operated Trap

The construction of this Trap obviates all possibility of steam waste, there is no leaking, no dripping and spitting. Its action is positive. Its discharge is like a shot from a gun. There is no wire drawing cutting. It has a great delivery and a greater and more positive discharge than any other trap.

No matter how low it is placed its discharge is strong enough to throw the contents to the height of an ordinary two story building. There is positively no trap duty that it will not perform, you can not realize the enormous capacity of this trap until you have made a careful study of its construction or seen one in operation.

Safety Feed Wat

is now recognized by leading engineers everywhere as one o auxiliaries, second only to the safety valve and the engin gover

It maintains a uniform water level in the boilers wh h cann mitting even and economical firing with inevitable sa ng in expansion which results from admitting sudden large do s of wa ductility of the boiler metal. It protects the engine fr m slug system. This dry steam feature alone is worth more tha the co ciency and the great saving in repairs. It never forgets—it neve for itself about twice annually in fuel, labor, dry steam a d savin

Nearly four million H. P. boilers in the better class of team p record of eight years without a repair and nobody ever he d of a

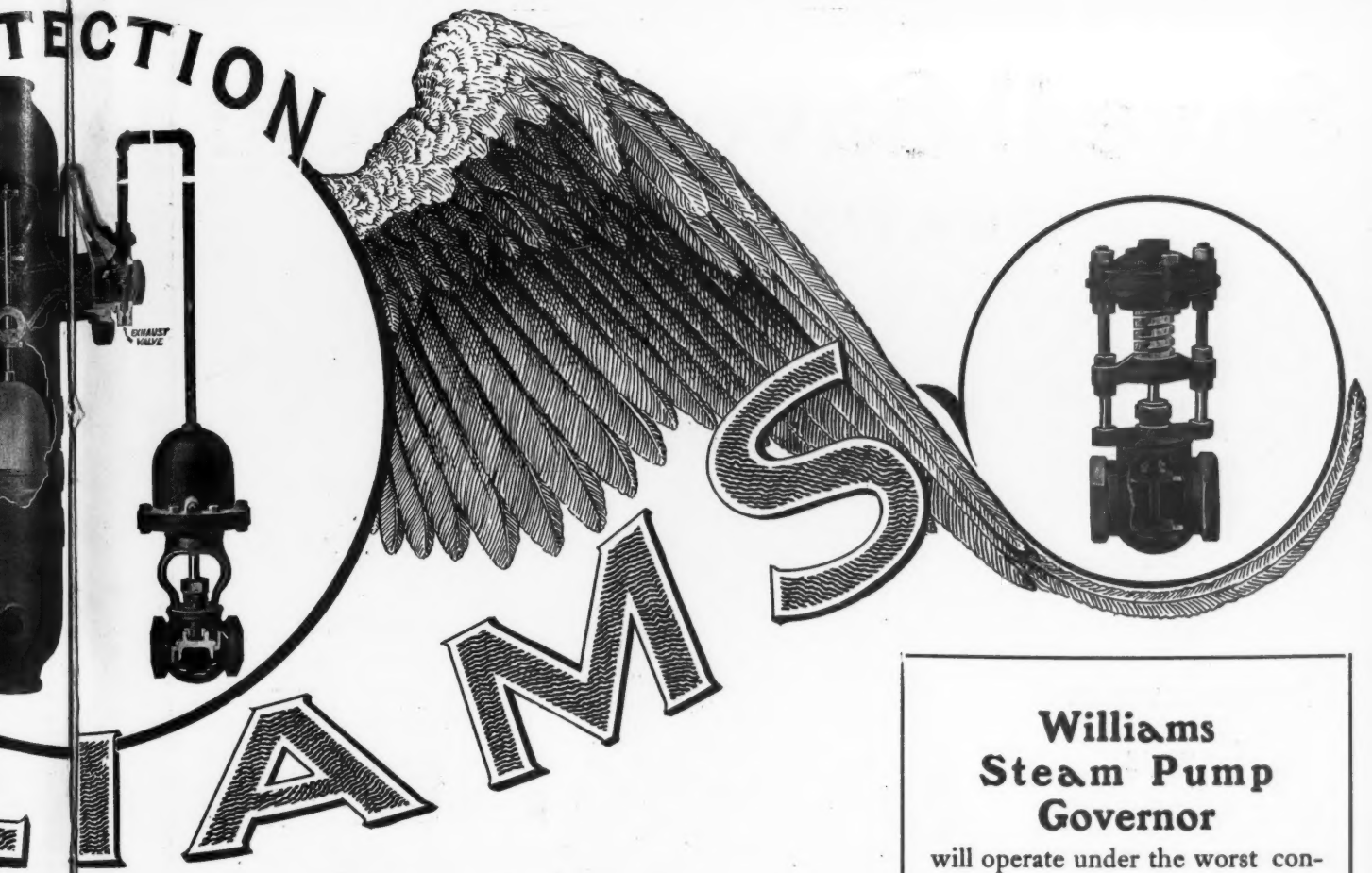
WILLIAMS NEW CATALCGUE NOW READY

STEAM SPECIALTY SPECIALISTS

The Williams Gauge Co.

New York Office, 39 Cortlandt St. Philadelphia Offi 718 G

TECTION



Water Regulator

here as one of the most important of modern power plant
e engine governor.

ers which cannot vary more than about half an inch, thus per-
ble saving in fuel. It obviates the dangerous contraction and
rge doses of water to the boiler, and which in time destroys the
gine from slugs of water and insures dry steam for the entire
ore than the cost of the regulator because of the increased effi-
orgets—it never sleeps—it never goes off duty. Besides paying
team and saving of repairs, it protects against boiler explosion.
lass of steam plants are operated daily by the Williams. It has a
ver heard of a boiler explosion where the Williams was in service

WRITE FOR A COPY TO DAY

Williams Steam Pump Governor

will operate under the worst conditions on a variation of less than two pounds pressure. Can you depend upon the governors you are using to do as well? It allows the water to run uniform all the time and it will operate in any position. It is made flanged or screwed and for any type of steam pump. It is simple in construction having few parts and nothing to get out of order, and it is the easiest of all pump governors to adjust. Since we first offered this governor to the public more of them have been sold than of all other makes combined. The U. S. Government uses them.

ge Co. Pittsburg, Pa. U.S.A.

hia Office, 718 Girard Bldg. Boston Office, 610 Tremont Bldg.

ORIGINATORS
NOT
IMITATORS

Saved! Saved! Saved!

WHAT'S SAVED?

1/3 the Cost of Incandescent Lamps

Order one Standard Package of Boston Renewed Lamps and Prove it

When you buy BOSTON Renewed Lamps

Which means Long Life High Efficiency and Low Cost

Special Price on Future Delivery Contracts for Quantity

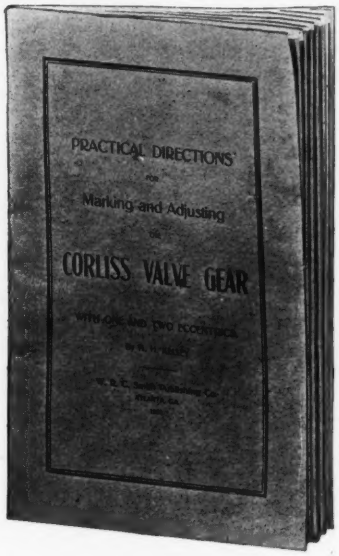
Special Souvenir will be given with orders placed during September to readers of The Practical Engineer

BOSTON TERRIERS AND BOSTON LAMPS ARE WINNERS

GET OUR PRICES

BOSTON INCANDESCENT LAMP CO.

DANVERS, MASS.



— *FREE* —

Send us your name and address, we will tell you how to obtain this valuable book, free of charge

50c. Absolutely New 50c.

Altogether Practical

PRACTICAL DIRECTIONS FOR ADJUSTING
THE
CORLISS VALVE GEAR
WITH
ONE AND TWO ECCENTRICS
(*illustrated*)

THIS work gives, in the plainest language and by means of illustrations, the simplest and surest method of correctly adjusting the Corliss valve gear that has yet appeared in print. It takes up the work step by step and goes into every detail so clearly and thoroughly that one who has not seen a Corliss valve gear would have no difficulty in adjusting the parts correctly. There is no need for shop marks on the valve gear when this booklet is at hand, for it not only explains, but shows how to set and mark all styles of single and double eccentric Corliss engine gears

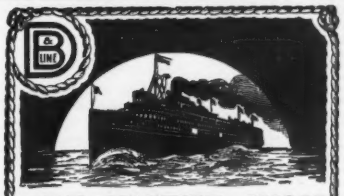
DON'T WAIT. SEND 50c. AT ONCE AND GET A COPY OR YOU MIGHT MISS IT

ADDRESS

W. R. C. Smith Publishing Co., Atlanta, Ga.

Subscription Agents Wanted

To solicit subscriptions for The Practical Engineer



THE WATER WAY
BETWEEN
Buffalo and Detroit

The D. & B. Line Steamers leave Buffalo daily at 5:30 p.m. (eastern time) and Detroit week days at 5:00 p.m., Sundays at 4:00 p.m. (central time) reaching their destination the next morning. Direct connections with early morning trains. Lowest rates and superior service to all points west.

Rail Tickets Available on Steamers

All classes of tickets sold reading via Michigan Central, Wabash and Grand Trunk Railways between Buffalo and Detroit, in either direction, will be accepted for transportation on D. & B. Line Steamers. Send 2 cent stamp for illustrated pamphlet. Address
A. A. SCHANTZ, G.S. & P.T.M., Detroit, Mich.
Detroit & Buffalo Steamboat Co.

Subscription Agents Wanted

A NEW BOOK ON

Mechanical Draft

by J. H Kinealy, M. Am. Soc. M. E.

Mr. Kinealy is a recognized authority on mechanical draft and in this book has covered the subject thoroughly.

He has had in mind the practicing engineer who is called upon to design power plants, and who must therefore decide when it is best to use some form of mechanical draft.

There are 156 pages, 13 plates, etc.

Price, Cloth, $2,00, post paid

Spon & Chamberlain
123 P. E. Liberty St., New York

The Smith Pipe Clamp

Stops The Leak Every Time

A complete set for every size of pipe in your plant will save many a dollar. Quickly applied while pressure is on the pipe WE GUARANTEE TO STOP THE LEAK. Steel or brass, all sizes, ¼-inch to 20-inch. No trouble to send further information.

W. CLIFFORD SMITH
138 N. SIXTH STREET
PHILA., PA., U. S. A.

D X N TRADE MARK

Engineers find Dixon's Flake Graphite of daily value for lubrication. It keeps bearings cool, saves wear and repairs and prevents frequent piston repacking. Do you use it?

Get our engineer's sample can "No. 96–C"—sent you Free on request.

JOSEPH DIXON CRUCIBLE CO
Jersey City, N. J.

The Best Lubricant

AIR
MICA FLAKE
FLOATED

Use it once and no other lubricant will ever satisfy you Greatest lubricant ever discovered. Try it on the worst bearing you have, or in your cylinder.

SAMPLE FREE
O. & W. A. WORNER
1529 Porter St. Philadelphia, Pa.

THE GENUINE
TRADE MARK REGISTERED
GANDY
PATENTED 1877

GENUINE GANDY

Keeps time with the Engine

In other words GANDY won't slip as do leather or rubber belts, consequently it transmits more power, thus increasing the efficiency of the Plant, without increasing the operating cost. Another point — GANDY, in spite of its advantages, is 10 to 25 per cent below rubber, and 50 to 75 per cent below leather belting in first cost. Isn't that worth investigating? Let us send you our booklet.

GANDY 6 PLY

GENUINE GANDY

GANDY BELTING CO.
BALTIMORE, MD.

FIRE AND WATER PROOF

In the great fire at Trostel's Tannery, in Milwaukee, Wis., a 24-inch 8-ply "LEVIATHAN BELT" was running within six feet of a brick wall that was subjected to an intense heat. Belt was thoroughly soaked with hot water and steam. It came through without injury, and is running to-day.

Such experiences as this one preach "LEVIATHAN" cheapness most eloquently. Shall we mail you a booklet?

MAIN BELTING COMPANY
Sole Manufacturers
1225-1235 Carpenter St. Phila.
55-57 Market Street, CHICAGO
40 Pearl Street, BUFFALO
120 Pearl Street, BOSTON
309 Broadway, NEW YORK

Red Seal Boiler Compounds

RED SEAL BOILER COMPOUND

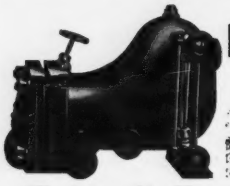
have been on the market over 13 years. Its sales are constantly increasing. Why? Because its quality and effectiveness are understood by intelligent engineers.

MANUFACTURED BY
THE CHERRY CHEMICAL CO.
No. 10 North 19th St., Philadelphia, Pa.
OLIVER BRADEN, Manager Write for Circulars

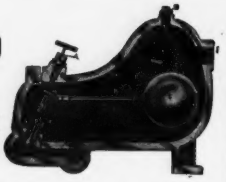
STEAM FITTING

if not properly done, in any plant, will cause the engineer a great deal of trouble, and his employer unnecessary expense. Many years of practical experience and a force of competent assistants enables me to guarantee absolute satisfaction.

WILLIAM MILLIGAN, Shop, 726 Sansom Street, Philadelphia, Pa.
'Phones: Bell-Walnut 1271 a Keystone-Main 1-71
JOBBING A SPECIALTY



McDANIEL
Improved Steam Trap



All the working parts are connected to the bonnet and are removable with it, making it most convenient to repair.

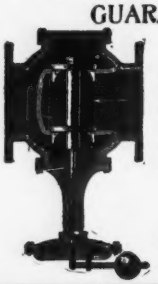
You never have to break a pipe joint they are all on the body.

We know this Trap will please you. May we send you one for trial.

Reducing Valves, Exhaust Pipe Heads, Ejectors, Relief Valves, Separators, etc.

ESTABLISHED 1878
SEND FOR 1905 CATALOGUE
WATSON & McDANIEL CO.
147 N. Seventh Street, Phila. Pa.

REDUCING VALVES FOR ALL SERVICES
GUARANTEED TO GIVE ENTIRE SATISFACTION



MANUFACTURERS OF

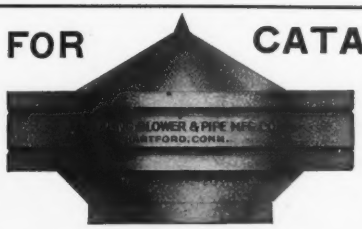
Steam Traps for all services, Damper Regulators, Back Pressure and Relief Valves, Grease Extractors, Steam Separators, Hot Water Temperature Controllers, Boiler Feeders, Tank Pump Controllers, Float Valves, Water Arches, Waste Heat Utilizers, Pump Regulators, Automatic Receivers and Pump Regulators, Water Feeders, Combination Muffler Tanks, Grease Extractors, etc.

Write for Catalogue.

KIELEY & MUELLER
34 West 13th Street, NEW YORK CITY
JAMES J. BROGAN, 810 Race Street, Philadelphia, Pa.

WRITE FOR CATALOG "L"

THE "STERLING" EXHAUST HEAD for separating condensation from Exhaust Steam. Causes absolutely no back pressure. SENT ON TRIAL FREIGHT PREPAID. For sale by contractors and supply houses.



THE "STERLING" VENTILATOR allows free egress of the air and is weather proof. The most durable, and efficient stationary ventilator made.

THE "STERLING" REVOLVING VENTILATOR is efficient, reliable and requires no power or attention, insures a high degree of ventilation.

The Sterling Blower and Pipe Mfg. Co., HARTFORD, CONN. N. Y. OFFICE:— 136 Liberty Street.

Goetze's

Elastic Copper Gaskets

For High Pressure Steam, Air Pressure and Superheat

It will pay you to investigate.
Send for a testing sample.
Holds where others fail.

Frederick Goetze, 725 E. 141st St., New York

ZENA

BEST HIGH-GRADE HIGH-PRESSURE PACKING

The toughest, most elastic and most pliable packing made A few turns used in connection with any packing you now have will improve that packing greatly.

Try it and you will always be a friend of Zena.

WRITE TO ME AND ASK ABOUT IT

RANDOLPH BRANDT, 70 Cortlandt St., New York

THAT DOUBLE PAGE

CENTRE POSITION

which is occupied by the advertisement of the Williams Gauge Company in this issue

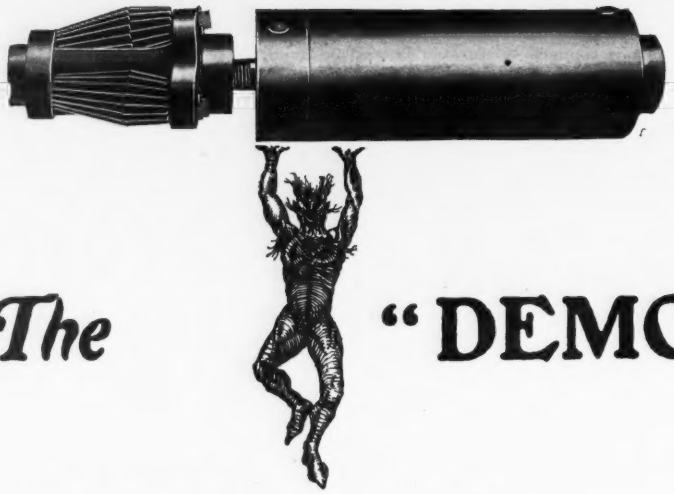
IS OPEN FOR NOVEMBER

GET IT

It offers a splendid opportunity for effective display and is unquestionably the most valuable advertising position in the engineering field.

A Pair Of *The* Best

TRY A "DEMON" FOR A COUPLE OF WEEKS



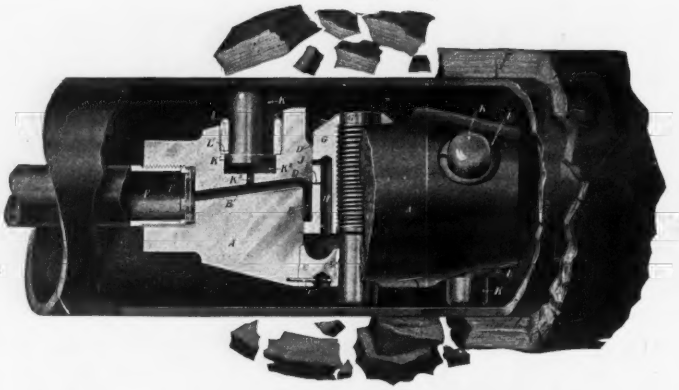
NOT A TURBINE BUT A ROTARY PISTON CLEANER

The "DEMON"

OPERATED BY WATER

The Demon is the most powerful and rapid water tube cleaner in the world. By actual test it develops over forty times the torque or twisting power of a turbine cleaner. The immense irresistible force of this cleaner renders it the quickest, the most thorough, and with all the most satisfactory cleaner ever used by engineers.

TAKE A TORPEDO ON FREE TRIAL



IT VIBRATES— NOT HAMMERS THE TUBES

The "TORPEDO"

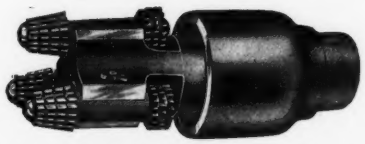
The Torpedo can make the scale fly from your tubes in your fire tube boilers. It operates with either steam or air. It produces 11,000 vibrations per minute and you can clean boilers at the rate of 3 to 5 minutes per tube.

READ— **A fair and square proposition to you.** **—READ**

Write us the kind of boilers and size of tubes and we will forward to you on Free Trial either of the above cleaners. Both are great money-savers. None better exists anywhere.

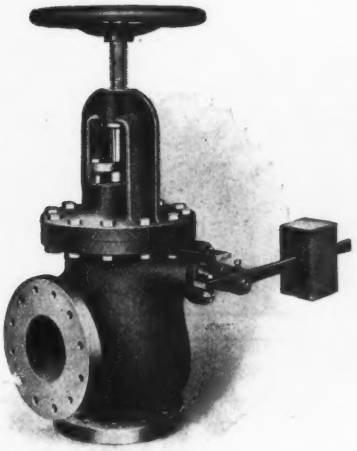
The General Specialty Co., 72 Carroll St., Buffalo, N.Y.

LAGONDA MONEY SAVERS



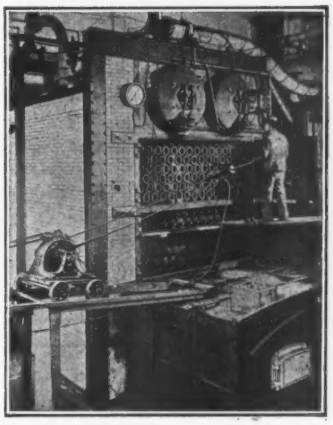
The Weinland Turbine Boiler Tube Cleaner

is the easiest cleaner to run, makes faster time cleaning, uses less water than others, and above all it thoroughly removes all scale that can be removed by any turbine cleaner. Hardened cutting stars, held by tempered pins in tempered arms, prolong the life of the wearing parts. Different heads are supplied for different kinds of scale. The ball bearings economize water. The balls and races are the best procurable, not the common kind used by others. Sent on approval, and if it doesn't do all we claim, you keep your money. Write for Booklet 21D.



The Lagonda Automatic Cut-Off Valve

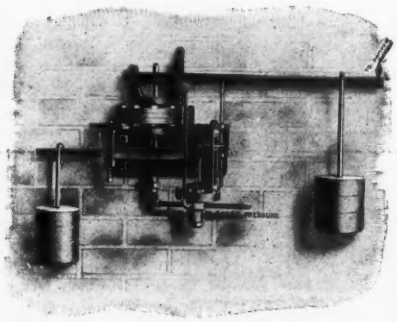
is essential to the safety and uninterrupted operation of your plant. It cuts out the boilers in case of an accident to the steam main, protecting everyone in the boiler or engine rooms. If a tube bursts, it shuts off that boiler from the others without interfering with the rest of the battery. It may also be used as a stop valve. It contains but two moving parts, one of which is in plain sight. It can be set for any desired output. When once set, no further attention is required. It insures your plant against shut-down, and may save lives. Sent on trial to boiler owners. Write for price list and Special Catalog 21E.



The Weinland Mechanical Tube Cleaner

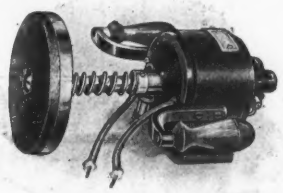
bores into and cuts away the worst scale, no matter how hard or thick. The screw of the cleaner head bores into the scale, the cone cutters loosen up heavy deposits, and then the straight cutters polish out the tube. There is no chance of injury to the tubes, for the straight cutters are held out only by centrifugal force. This cleaner may be driven by an electric motor, steam or gasoline engine or powerful water motor, and is adaptable to any water tube boiler whether the tubes are straight or curved. A water motor can be attached directly to the boring bar, without belts or gears.

Write for Book 21A. Also see the chapter of this advertisement on "Cleaning Boilers by Contract."



The Lagonda Damper Regulator

is more watchful than the fireman. It maintains a constant steam pressure, saves coal by preventing excessive air supply and needless blowing off of the safety valve. It is connected directly to the boiler pressure and is actuated by slight variation of steam pressure. None of the parts are intricate, and the only wearing out part is the diaphragm, which has an armor protection. There are no piston rods to wear nor stuffing boxes to leak. It can also be used to regulate the speed of draft fans.



The Lagonda Reseating Machine

removes all the scale and dirt from the caps, header faces and nuts of a B. & W. or other water tube boiler in an hour. It saves three-quarters of the hand labor, and the work is **perfectly** done instead of partially. This machine is furnished with a water or an electric motor and can be carried anywhere.

The Lagonda Tube Cutter

is needed in every boiler room. It cuts tubes from any style of boiler at any point of the tube. Your handy man can cut a 4-inch tube slick and clean in 55 seconds. This tool is as simple as it is inexpensive, and saves the time and cost of sending for the boilermaker. Send for one. We will take it back if it doesn't fill the bill.

WE CLEAN BOILERS BY CONTRACT. We clean boilers, condensers, economizers, etc., on short notice, and do a good job every time. We have been 20 years at it. Don't wait until you can't get up enough steam to blow the whistle, but write to us. Our Mr. Weinland has studied boiler troubles and is the original inventor of the best boiler tube cleaners on the market. We have never found a case of boiler scale so bad that he was stumped. We clean boilers by contract, sell or rent machines, and give expert advice on boiler room subjects. Tell us your troubles.

***The* Lagonda Mfg. Co., Springfield, O.** BOILER CLEANING EXPERTS— 20 Years At It.

NEW YORK PITTSBURG PHILADELPHIA CHICAGO SAN FRANCISCO

GEO. H. GIBSON CO. PARK ROW NEW YORK

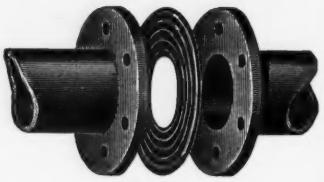
CASH PAID FOR SECOND-HAND BELTING

ALL SIZES BELTING ON HAND

FOR SALE

W. T. SHACKLEY & SONS, (ESTABLISHED 1886) 49 High Street, Boston, Mass.

CORRUGATED COPPER GASKETS



SAVE STEAM and make ABSOLUTELY TIGHT JOINTS

Best and Cheapest—Samples Free.

UNITED STATES MINERAL WOOL CO., 143 Liberty St., New York

O. F. ZURN J. M. ZURN J. D. KELLEY C. J. CURRAN

We Are Hunting Trouble!

"OLEAQUA" Hydraulic Compound
"PEERLESS" Boiler Compounds
} THE CURE

Oleaqua is the best Compound made for Cleaning and Preserving Elevator Systems. Write for Circular

High Grade Lubricating Oils and Greases
QUALITY is our first and last consideration

O. F. ZURN CO.
23 and 25 S. Fifth St. PHILA, PA.

If your packing chars or burns, or becomes hard and scores the rods, or if you have any rods where the pressure is such that they need constant repacking. Try the

GLADIATOR ASBESTO-METALLIC HIGH PRESSURE RING PACKING

The ring that's "Molded" in steel dies under hydraulic pressure, and made to the exact measurement of the rods it is intended to pack. We'll guarantee it to relieve you of your troubles, and what is more—it will save you money.

NEW JERSEY ASBESTOS CO. - - - - - - CAMDEN, N. J.

If you want the best get Gould's Steam and Water Packing

RING PACKING

In ordering give EXACT diameter of stuffing box and piston rod or valve stem.

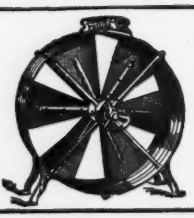
See that our name and trademark is on every package.

Gould's STEAM AND WATER Packing

Gould Packing Co.

E. Cambridge, Mass. REGISTERED TRADE MARK

Albion Chipman, Treas. East Cambridge, Mass.



CIRCULATING AND EXHAUST FANS FOR VENTILATING PURPOSES

If you are troubled with Heat, Steam, Smoke, or poisonous gases, this wheel will remove them

Prices on Application. Send for Circular.

JOSEPH CARR, Manufacturer

132 N. Seventh St. Philadelphia

WE MAKE A SPECIALTY OF ALL KINDS OF

Hydraulic Repair Works

ENGINE AND STEAM PUMP REPAIRS

Special attention to erection of engines, boilers, pumps, Hot-Air Pumping Engines, etc. Our work the best and charges moderate.

PHILADELPHIA HYDRAULIC WORKS

1218 Cuthbert Street, PHILADELPHIA, PA.

H. A. ROGERS COMPANY • PERTH GAUGE GLASS • J. MONCRIEFF, MAKER PERTH • SOLE AGENTS FOR UNITED STATES • TRADE MARK

THE CELEBRATED

Moncrieff SCOTCH Gauge Glasses

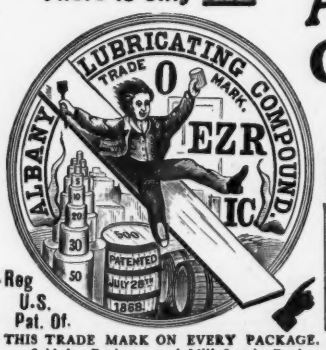
ENGINEERS KNOW and appreciate the many good qualities of which we are the sole importers and distributors.

Machine Tools and Wood Working Machinery
Engineers and Contractors Supplies, and Equipment

SEND FOR SPECIFICATIONS AND PRICES

H. A. Rogers Co. 19 JOHN ST. NEW YORK

There is only ONE



Reg U.S. Pat. Of.

THIS TRADE MARK ON EVERY PACKAGE. Sold by Engineers and Mill Supply Dealers the World over.

ALBANY GREASE

and we are the only makers

LUBRICATES EVERYTHING

Adapted to all kinds of machinery

Cost of using oil

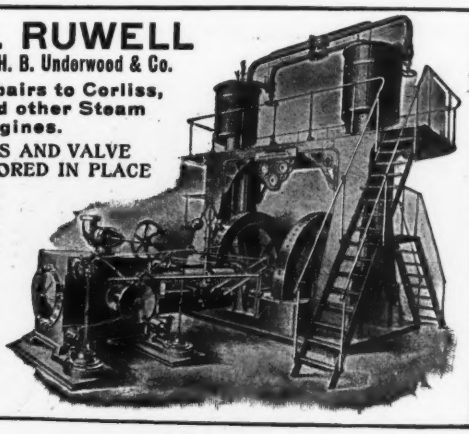
Cost of using Albany Grease

Our Special Offer. A sample can of Albany Grease with an Albany Grease Cup free of charge or expense for testing.

The only information necessary to send is, pipe connection in bearing, depth of oil hole from top of cap to journal, and give particular part of machinery on which the same is to be tested.

ADAM COOK'S SONS
313 West St., N. Y. City

W. F. RUWELL
Late with H. B. Underwood & Co.
General Repairs to Corliss, Greene and other Steam Engines.
CYLINDERS AND VALVE SEATS REBORED IN PLACE
We make a specialty of repairing Ice Machines and Pumps. All work guaranteed strictly first class.
Office and Works.
719-721 Noble Street
PHILADELPHIA
Tele. Connection
We make a specialty of Metallic Packing or Piston Rods.

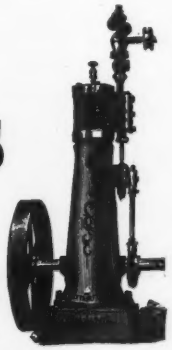


For Three Subscriptions
to The Practical Engineer at Fifty Cents Each, we will send Free a Copy of
ALGEBRA SELF-TAUGHT
By W. P. HIGGS
This is a most excellent book that commences at the very beginning and goes step by step from one stage to another. It is simply written and easily understood.
Every young engineer should have one of these books. The study of Algebra is intensly interesting and a knowledge of it is a valuable possession.
One Subscription to The Practical Engineer and a Copy of Algebra Self-Taught for One Dollar.
ADDRESS THE PRACTICAL ENGINEER
46 North Twelfth Street, PHILADELPHIA, PA.

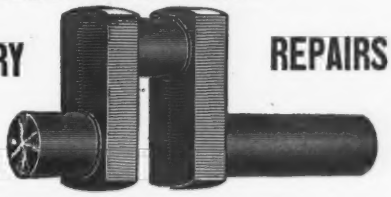
Telephone **EAGLE IRON WORKS** Established 1851
Reilly & Fearon Co.
Successors to Hoff & Fontaine
MANUFACTURERS OF
Engines, Boilers, Stacks and Tanks
General Machinists' and Iron Founders
1152-1164 NORTH THIRD STREET, PHILADELPHIA, PA.
Complete Power Plants Steam Fitting Cylinders Bored in Position
General Repairs to Ice Machinery, Engines Boilers, Pumps Etc.

Bridgman Bros. Co.
MANUFACTURERS OF
IRON AND BRASS VALVES, FITTINGS, ETC.
FOR
STEAM, GAS, WATER AND OIL
Brass Castings
A SPECIALTY
Wrought Iron Pipe
1422-24-26 Washington Ave., PHILADELPHIA
AGENCIES:—RICHARDSON BOILERS—NATIONAL RADIATION

ESTABLISHED 1871
J. & G. RICH
General Machinists
ENGINE BUILDERS
AND DEALERS IN MACHINERY
Especial Attention Given to Repairing and Erecting Steam Engines, Pumps and other Machinery, Shafting, Hangers, Pulleys, Etc.
120 NORTH SIXTH STREET, PHILADELPHIA, PA.
TELEPHONE



JAMES GEMMELL Phones—Bell 42-69 D Keystone 44-65 D
CYLINDERS OF ENGINES AND PUMPS REBORED IN PLACE
MACHINERY REPAIRS
STACKS, TANKS

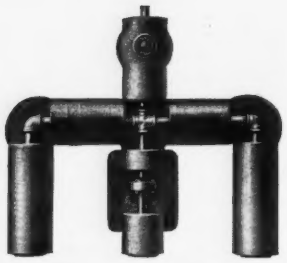


General Engineering Co.
Engineers, Boiler Makers, Blacksmiths
J. GEMMELL, Supt. Phila., Pa. 764 Swanson St.

Tulley's Hand-Book on Engineering
for Men Operating Steam and Electrical Machinery
and all STEAM USERS, ELECTRICIANS, FIREMEN and MACHINISTS

An encyclopedia of information, and in itself the most complete library of Engineering ever published. It is thoroughly reliable and practical; it is not only a guide but a teacher.
As a reference and text-book it is the fullest, latest and best authority on the subjects treated. It extends to detail not found elsewhere. Indorsed by the foremost practical men in the world. Handsomely bound in eather and gilt. **Pocket-book form.**
A 64-page illustrated pamphlet, describing the book, will be mailed for the asking.
Sent anywhere on receipt of price. $3.50. **Money back if not satisfactory.**
HENRY C. TULLEY & CO.
Fifth Edition. 990 pages, 400 illustrations. **409 Wainwright Building** **ST. LOUIS, MO., U. S. A.**

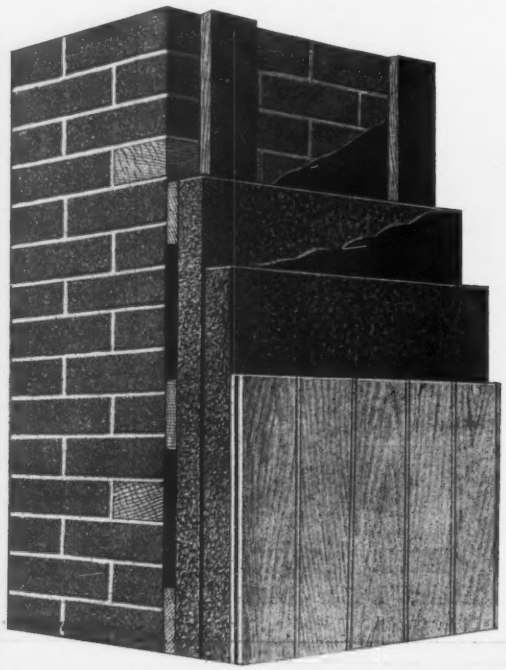
NONPAREIL CORK

Pipe  Coverings

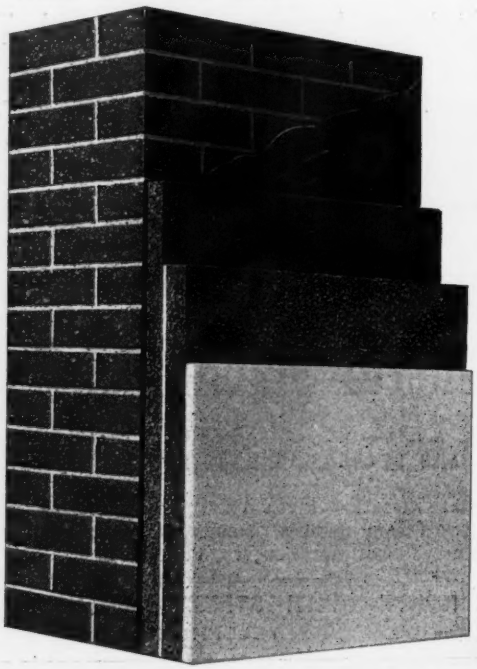
THE BEST Cold Pipe Coverings

We also apply Asbestos, Magnesia, Air Cell and Wool Felt.

OUR WORKMANSHIP AND MATERIAL WILL PLEASE YOU.



Sheet Cork INSULATION FOR Cold Storage Rooms is the Best



We have the most up-to-date data on Cold Storage Insulation Values.—Our Methods are Modern.—Our Prices Fair.—Our Nonpareil Marble Finish—A substitute for Wool—Is Fire Proof and Water Proof.

SPECIFICATIONS AND ESTIMATES FURNISHED

John R. Livezey
1936 Sansom Street
PHILADELPHIA, PA.

Nonpareil Cork Works
105 Hudson Street, NEW YORK

John R. Livezey
612 E. St. N. W. Washington, D. C.
L. P. MENCHINE, Mgr.

DEARBORN LABORATORIES

Have introduced Chemistry in the scientific, correct and economical treatment of boiler waters. Gallon samples of the feed water are analyzed from time to time, and the treatment furnished constantly meets requirements in the prevention of scale, corrosion, foaming or such troubles as each particular water may produce.

DEARBORN TREATMENT will positively keep your boilers clean and well preserved.

DEARBORN TREATMENT is made on such lines that the quantity required to treat each thousand gallons of water is small, consequently its use is economical.

You are further assured that a house of chemical standing will use no materials that in themselves would be injurious to your boiler plant.

If you have not adopted Dearborn Water Treatment as thousands have done, send us gallon of water for analysis and proposition.

DEARBORN DRUG AND CHEMICAL WORKS

WM. H. EDGAR, Founder

LABORATORIES AND WORKS, CHICAGO

NEW YORK
299 Broadway

Philadelphia Office:—The Bourse

CHICAGO
226-234 Postal Telegraph Bldg

BRANCH OFFICES

BALTIMORE, Cont. Trust Bldg.
BIRMINGHAM, First National Bank Building
CINCINNATI, Union Trust Building
BUFFALO, Morgan Building
BOSTON, Oliver Building
PITTSBURG, House Building
INDIANAPOLIS, IND.

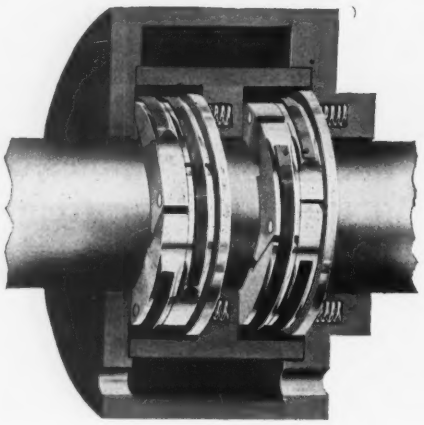
DETROIT, Majestic Building
ST. LOUIS, Security Building
KANSAS CITY, New York Life Building
ST. PAUL, 1237 Lincoln Avenue
MILWAUKEE, WIS.
PEORIA, ILL.

DENVER, Boston Block
SALT LAKE CITY, Dooly Block
SAN FRANCISCO, 115 Davis Street
LOS ANGELES, 355 E. Second Street
HONOLULU, 42 Queen Street
HAVANA, Tacon 8.

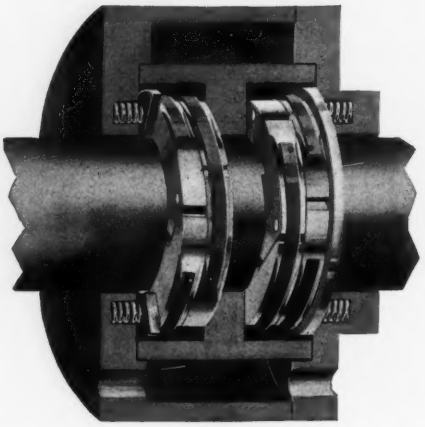
TRIPP METALLIC PACKING

IMPROVED TYPE

FOR HIGH PRESSURE



FOR LOW PRESSURE



None genuine unless stamped with our name and cage number.

W. B. MERRILL & CO.,

74 INDIA STREET. SOLE MANUFACTURERS OF TRIPP METALLIC PACKING BOSTON, MASS.

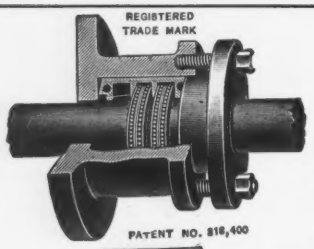
The United States Metallic Packing Co.

PHILADELPHIA AND CHICAGO

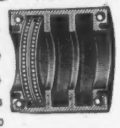
WRITE FOR NEW PREMIUM CIRCULAR

We have added several new and useful articles to our list of premiums for procuring subscribers to The Practical Engineer and we want all our engineer friends to get up a Club. Write for circular The Practical Engineer, 46 N. 12th St., Phila., Pa

REGISTERED TRADE MARK



PATENT NO. 818,400



PAT. NO. 456,177 " " 500,699 " " 534,104 " " 602,828 " " 774,490

PAT. NO. 654,941 " " 654,942 " " 725,368 " " 775,193 " " 775,196

Holmes Packing

is now recognized as being superior to all others and is a common name among engineers

First cost, only cost. Guaranteed 3 years. No Cutting. No Friction. Less Oil. Thirty Days Trial.

Send for Catalogue H.

Holmes Metallic Packing Co. WILKES-BARRE PENNA.

FREE To Any Engineer

A TABOR CROSBY OR AMERICAN-THOMPSON

INDICATOR

Also 500 other things including every article, tool or device an engineer may want. For Free premium list and full particulars regarding this remarkable offer, fill out and mail us the coupon below.

FRANCE PACKING CO., Inc.

State Road, Tacony, Philadelphia

MANUFACTURERS OF

METALLIC, FIBROUS AND SHEET PACKINGS

Tear OFF Here

Date, 1904.

FRANCE PACKING CO.,
State Rd., Tacony, Philad'a.

Gentlemen:

Kindly send me premium list and full particulars regarding the indicators and other articles you are giving to engineers.

My name is

My address is

I am employed by

Give Complete Address.

The Ashton Quality

POP SAFETY VALVES
RELIEF VALVES
BLOW - OFF VALVES

can be trusted at all times, being of a superior quality and guaranteed to give perfect satisfaction.

Send for catalog "D"

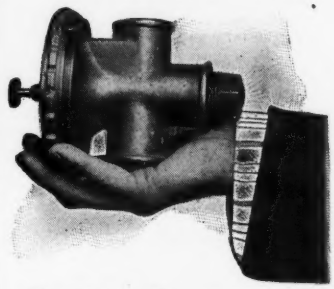
THE ASHTON VALVE CO.
271 Franklin St.
Boston, Mass.

STEAM AND VACUUM GAGES
RECORDING GAGES

are absolutely accurate and reliable, having non-corrosive movements.

BRANCH STORES
110 Liberty St., New York
142 N. 6th St., Phila., Pa.
Frick Bldg. Pittsburg, Pa.
160 Lake St , Chicago, Ill.
2 Pine St., Sa Francisco, Cal.

DUNHAM STEAM TRAPS



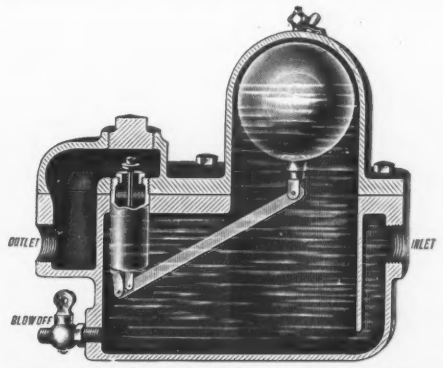
For Every Service.

We offer to send one on 30 days trial to prove its merits—to convince you that it **does the business.**

Write us your requirements and we will tell you all about it.

C. A. Dunham Co.
Marshalltown, Iowa

Resident Manager, L. BANCROFT MELLOR
No. 14 S. Fourth Street, Philadelphia, Pa.



THE WRIGHT "VICTOR" LOW PRESSURE STEAM TRAP

Never ceases operating even though the Pressure Registers O.

AN ADMITTED AND VALUED ADVANTAGE OVER ALL OTHER LOW PRESSURE TRAPS

Absolutely the Best Steam Trap made for use in Heating systems—The operation is guaranteed perfect on all pressures from 0 to 20 pounds.

Send for Catalogue containing full information and illustrating exclusive points of value

WRIGHT MANUFACTURING CO.
72 Woodbridge St., Detroit, Mich.

What's *the* Difference?

30-Days Trial will prove that Lindstrom's Liberating Valve *Steam Trap* is a wonder. *The only Successful Steam Trap.* It takes care of itself.—No parts to get out of order.—The Valve never leaves the Seat.—No scale can get between Seat and Valve. The Lid is ground, no packing needed

The Slate Belt Electric Street Railway Company
BETHLEHEM, PENNSYLVANIA

Office of Superintendent

Pen Argyl, Pa., April 27, 1906

Mr. JOHN T. LINDSTROM, M. E.,
214-216 S 3rd. Street,
Allentown, Pa.

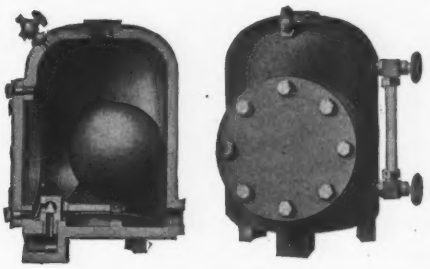
Dear Sir:

I wish to advise you that the Corliss Valve Steam Traps purchased from you are giving excellent satisfaction. We consider them the best in the market.

Yours very truly,
J. T. Hambleton, Supt.

Special Discount during the next 2 Months.

Send for New Catalogue L.



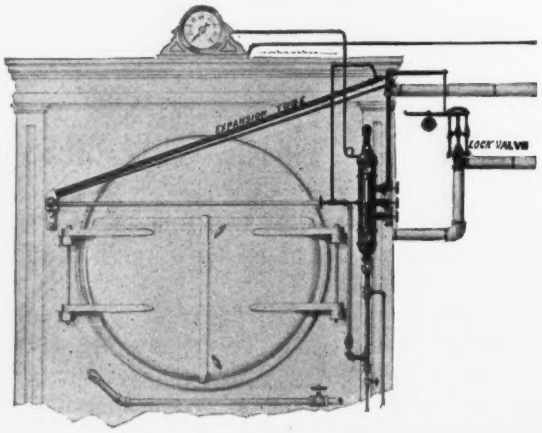
MANUFACTURED BY
John T. Lindstrom
214-216 S. Third Street
ALLENTOWN, PENNA.

PHILADELPHIA AGENTS
American Boiler Economy Co.
420 MUTUAL LIFE BLDG., PHILADELPHIA, PA.

EXPERIENCE TELLS THE TALE

Read what one user says of the

Copes Boiler-Feed Regulator



THE BELL TELEPHONE COMPANY OF PHILADELPHIA.

Philadelphia, April 6, 1906.

American Boiler Economy Company, Philadelphia, Pa.

Gentlemen:—

In reply to your inquiry as to our experience with the COPES REGULATOR AND PUMP GOVERNOR, I am pleased to forward you the following facts:

1—During nine years of constant service at our Eleventh and Filbert streets plant, your device has given perfect satisfaction in every respect.

2—The Regulator has cost us nothing for repairs in that time, and the total cost of repairs to the four Pump Governors has been $3.50.

3—No adjustment has been required since the installation of the device.

When we started our Seventeenth and Filbert streets plant, we ran for three years without a Regulator. Our feed water, coming from the heater was so hot that we had a great deal of trouble with our pump becoming vapor-bound, causing it to race and destroy the packing, which we had to renew two or three times a week. Since we have had the Copes Regulators installed the pump does not race and requires packing on an average of once every eight months only.

Our coal records show a saving of three and a half per cent. with the Regulator in service.

Our two plants, at Eliventh and Filbert streets and Seventeenth and Filbert streets are completely equipped with the Copes Regulators and Pump Governors.

The two plants are also completely equipped with your House-Tank Regulators, which are giving complete satisfaction. Yours very truly,

JOSEPH W. SAVIN, Chief Engineer.

AMERICAN BOILER ECONOMY CO., 420 Mutual Life Building, Philadelphia, Pa.

Successor to WILFONG & WILTBANK

AGENTS FOR NEW ENGLAND STATES,
The New England Roller Grate Co., Whitney Building, Springfield, Mass.

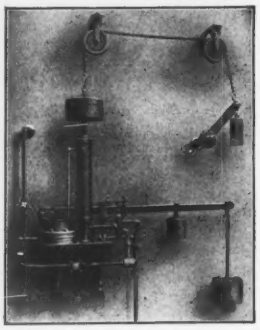
REPRESENTATIVE FOR MARYLAND AND DISTRICT OF COLUMBIA
John H. Walter, 1227 W. Lafayette Ave., Baltimore, Md.

$50 PATTERSON

(Perfected) Graduated Scale Beam

Hydraulic Damper Regulator

(NO. 2 MOD. L)



"We have won first place in Hydraulic

Damper Regulators

Selling by Giving a $75. value for $50."

Scientifically designed, simple in construction. Will handle 1 to 20 dampers on one pound variation of boiler pressure.

When we say the Patterson (Perfected) Hydraulic Damper Regulator is the best made, we can prove it.

Sent anywhere on 30 days trial.
Satisfaction guaranteed or no pay.

Patterson Manufacturing Co.

4 SOUTH FRONT ST., BALTIMORE, MD.

American Water Softener

Would you swallow poison because you know the Antidote?
Then why do you feed Hard Water to your Boilers
Boiler Compounds and Cleaners are only Antidotes and a Boiler, to do its proper duties must first be rid of Poison and Antidote alike.

OUR CATALOGUE GIVES A FEW HINTS

AMERICAN WATER SOFTENER CO.

1002 Mutual Life Bldg., Philadelphia, Pa.
302 Outlook Bldg., Columbus, Ohio

MORRIS G. CONDON
ALBERT D. PEDRICK
EDWIN J. ROOKSBY

L. B. FLANDERS MACHINE WORKS.
ESTABLISHED 1870.

Sole Makers of
ST. JOHN SELF ADJUSTING
CYLINDER PACKING.

H. B. UNDERWOOD & CO.
GENERAL MACHINISTS.

1025 HAMILTON STREET PHILADELPHIA, PA.

The Home of the Underwood Repair Shops

Best equipped Engine repair shop in America

Cylinders rebored in position ; Valves reseated in position. Men and tools sent anywhere at short notice

MORRIS G. CONDON
ALBERT D. PEDRICK
EDWIN J. ROOKSBY

L. B. FLANDERS MACHINE WORKS.
ESTABLISHED 1870

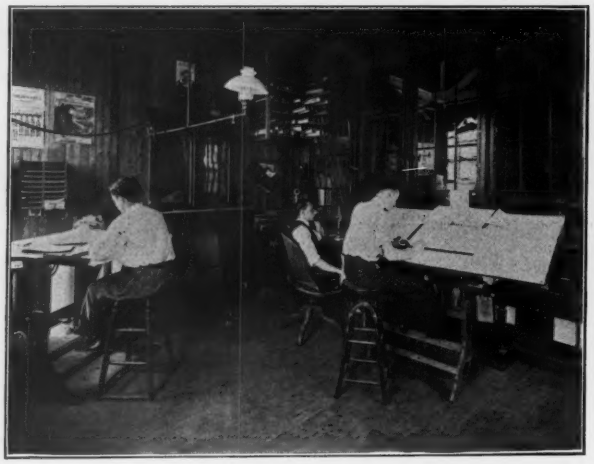
Sole Makers of
ST. JOHN SELF ADJUSTING
CYLINDER PACKING.

H. B. UNDERWOOD & CO.

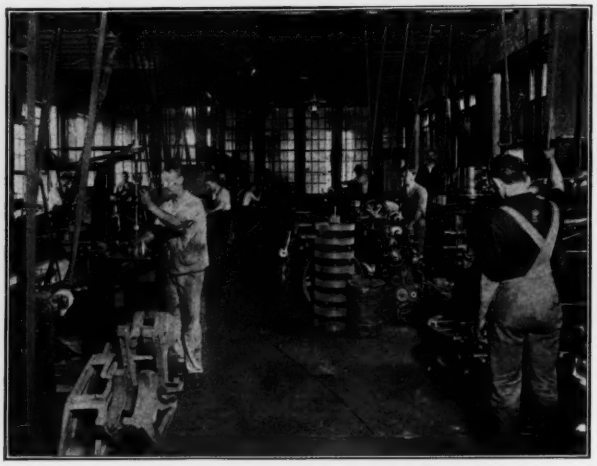
GENERAL MACHINISTS.

1025 HAMILTON STREET PHILADELPHIA, PA.

STEAM ENGINE REPAIRS



Drafting Room



Portable Tool Department where Lathe Work, Drilling, Gear Cutting, Bench Work and Keyseating are done

STEAM PUMP REPAIRS

Pattern Shop—Showing Band Saw, Lathes and Pattern Racks

Another View of Pattern Shop—Showing Pattern of a 60-inch St. John Packing and Crosshead for 16-foot Boring-Bar

GENERAL MACHINE WORK

MORRIS G. CONDON
ALBERT D. PEDRICK
EDWIN J. ROOKSBY

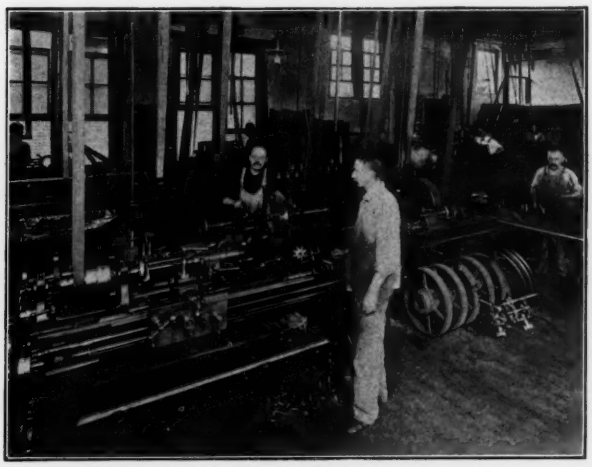
L. B. FLANDERS MACHINE WORKS.
ESTABLISHED 1870.

Sole Makers of
ST. JOHN SELF ADJUSTING
CYLINDER PACKING.

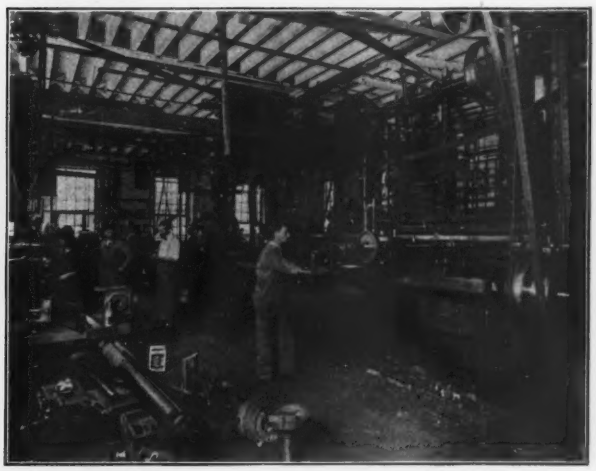
H. B. UNDERWOOD & CO.

GENERAL MACHINISTS,

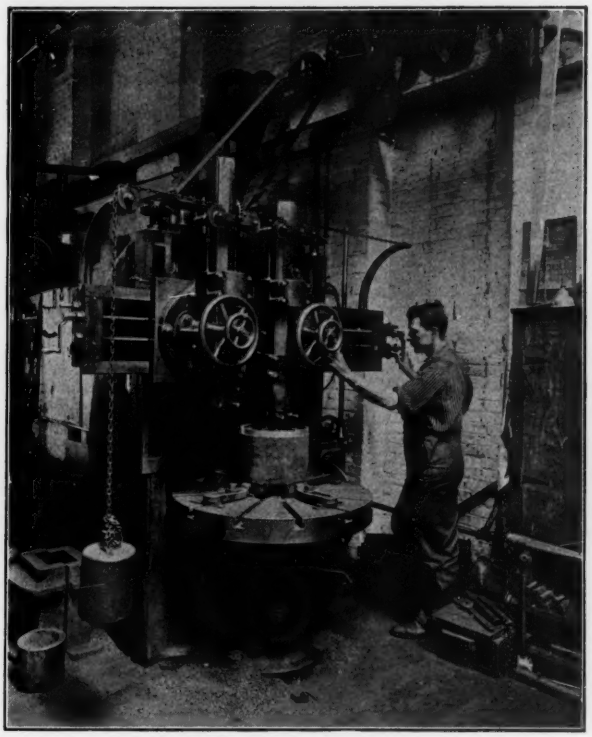
1025 HAMILTON STREET PHILADELPHIA, PA.



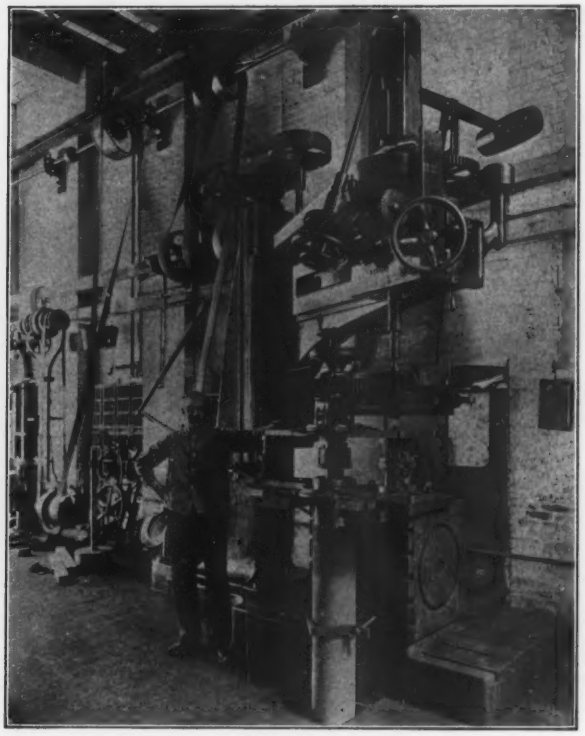
14-inch Lathes in Portable Tool Department



General View of One of the Repair Shops where the Break-down Jobs are Handled and where Speed and Accuracy are the Requirements



36-inch Boring Mill—Used for Smaller Pistons and St. John Packings



5-foot Drill equipped with special rig for Boring Brass Tubes and used for making Portable Tools

PORTABLE TOOLS—EXPERT WORKMEN

MORRIS G. CONDON
ALBERT D. PEDRICK
EDWIN J. ROOKSBY

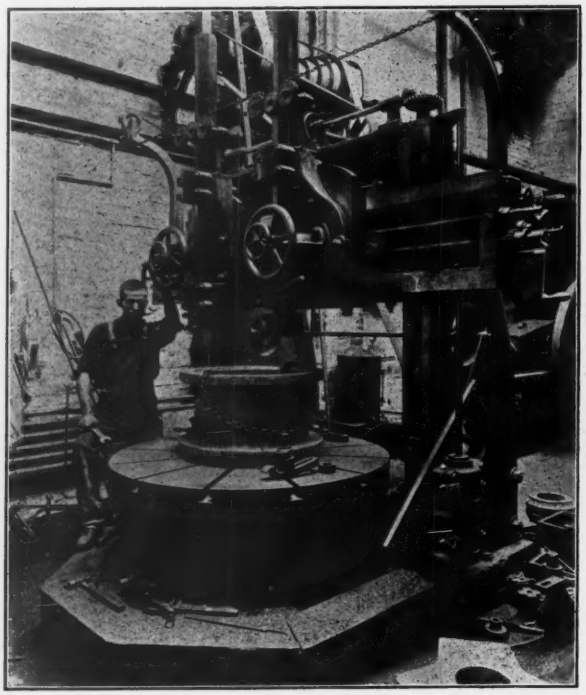
L. B. FLANDERS MACHINE WORKS.
ESTABLISHED 1870.

Sole Makers of
ST. JOHN SELF ADJUSTING
CYLINDER PACKING.

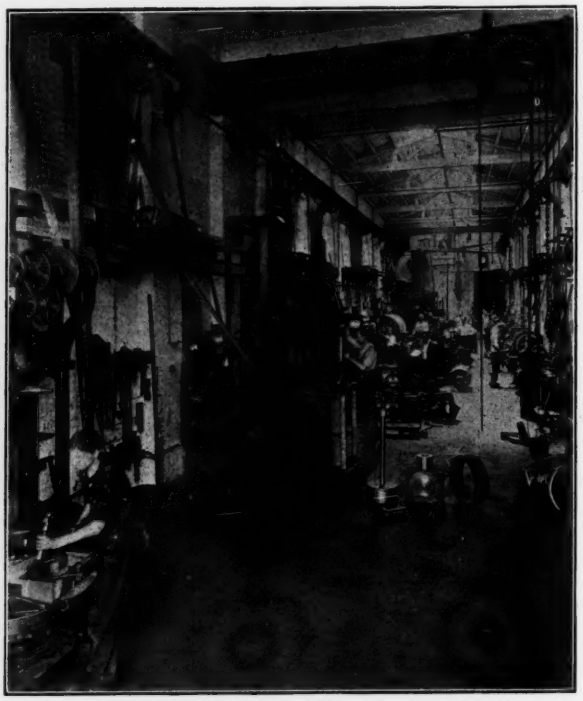
H. B. UNDERWOOD & CO.

GENERAL MACHINISTS,

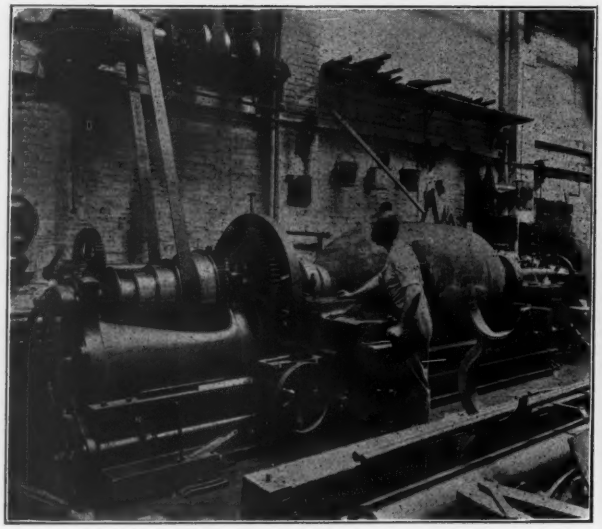
1025 HAMILTON STREET PHILADELPHIA, PA.



60-inch Boring Mill used for Turning large Pistons and Rings



Repair Shop showing Machinery used in Engine Repairs



60-inch Lathe turning a 16,000 pound casting.

Entrance to the Main Offices

WE GO ANYWHERE AT ANY TIME

Hawkins Works

In again asking the attention of the Mechanical World to the

ENGINEERS' STANDARD LIBRARY

and the "little at a time" payment plan, on which these books are supplied, the publishers wish to express their appreciation of the hearty support and endorsement tendered by those who have been and continue to be students of engineering, electricity and mechanical drawing.

The Hawkins' Works are kept constantly "up to the times" by frequent revisions and additions by the author; to this fact is undoubtedly largely due their continued popularity.

The seven volumes which comprise the author's complete works, are supplied to responsible parties on the one dollar monthly payment plan; the complete library is delivered to the subscriber, express or post prepaid, upon receipt of the first payment of one dollar, the balance to be sent one dollar monthly to publishers, by post-office or express money order. See order coupon below.

LIST OF SERIES

I. **Hawkins' Self-Help, Mechanical Drawing**, price post paid, $2.

II. **Hawkins' New Catechism of Electricity**, price post paid, 2.

III. **Hawkins' Aids to Engineers' Examinations**, price post paid, 2. (*With Questions and Answers.*)

IV. **Hawkins' Maxims and Instructions for the Boiler Room**, price post paid, 2.

V. **Hawkins' Hand Book of Calculations for Engineers**, price post paid, 2.

VI. **Hawkins' New Catechism of the Steam Engine**, price post paid, 2.

VII. **Hawkins' Indicator Catechism (A practical treatise)**, price post paid, 1.

When set is purchased, the seven volumes are supplied for $12.00 being a reduction of $1.00 from above list.

7 Volumes

$1 Monthly

Catalog Free
(SEND POSTAL)

ADDRESS
THEO. AUDEL & CO.
63 Fifth Avenue
New York

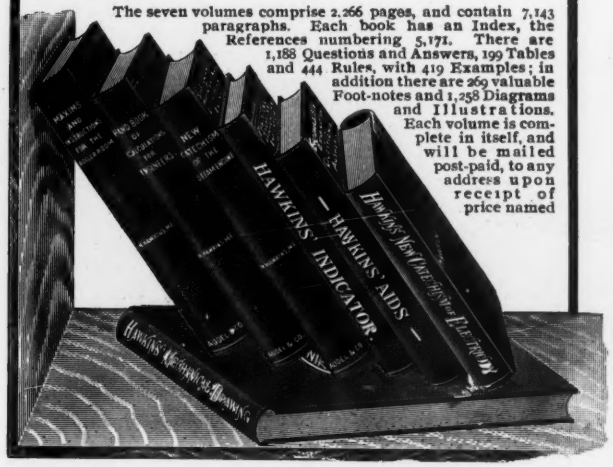
CUT OUT

ORDER COUPON

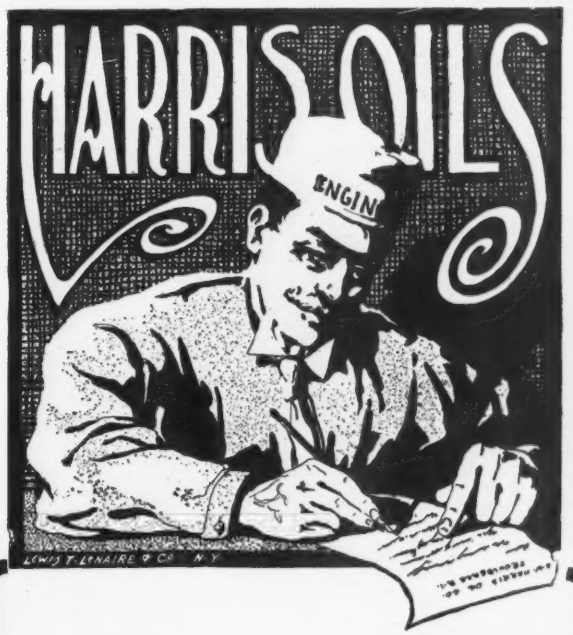
I accept your offer to supply the ENGINEERS' STANDARD LIBRARY for $12.00. Enclosed find One Dollar to cover my first payment, the balance I agree to remit $1.00 per month.

I can refer you as to my reliability to
.....
.....
.....

NAME.....
Address.....
.....
.....



The seven volumes comprise 2,266 pages, and contain 7,143 paragraphs. Each book has an Index, the References numbering 5,171. There are 1,188 Questions and Answers, 199 Tables and 444 Rules, with 419 Examples; in addition there are 269 valuable Foot-notes and 1,258 Diagrams and Illustrations. Each volume is complete in itself, and will be mailed post-paid, to any address upon receipt of price named



YOU know your engine lubricating troubles better—far better than we do.

What we know is how to overcome those troubles.

Put down in black and white all you can say about the troubles you are having with your engine, mail the whole thing to us and we tell you how to obviate them, or in other words, how you can remove them

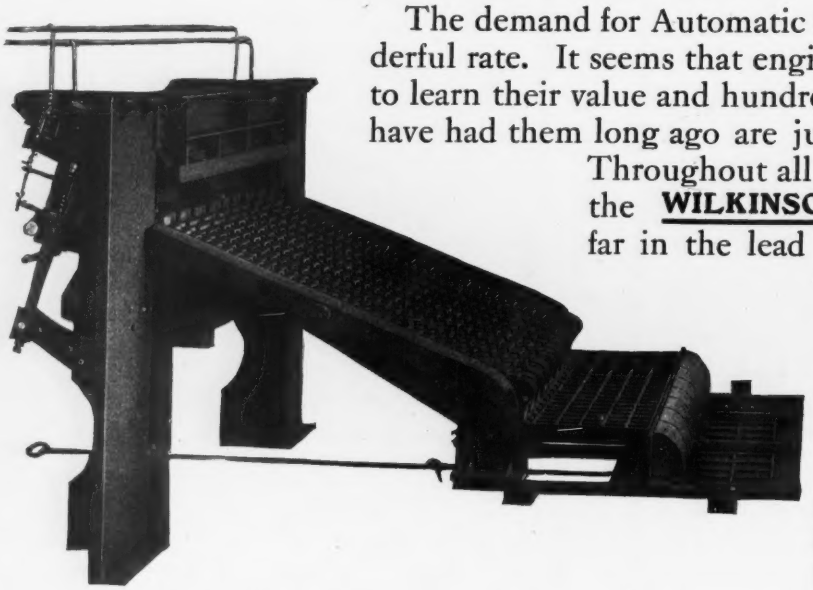
Most engineers who use Harris Valve Oil for internal use of the engine and Harris Engine Oil for external use, have no trouble with their engines.

Our catalogue of Harris Oils, which we send for the asking contains a fund of information on the subject of lubrication, and we have a proposition we will submit to you on request, which never fails to interest users of lubricating oils.

A. W. HARRIS OIL CO.

320 South Water Street, Providence, R. I.

THE WILKINSON LEADS



The demand for Automatic Stokers grows at a wonderful rate. It seems that engineers are just beginning to learn their value and hundreds of plants that should have had them long ago are just now installing them. Throughout all this increased demand the **WILKINSON STOKER** continues far in the lead of all others. Indeed there are probably more Wilkinson Stokers in use than of all others combined and still the demand for them grows

If you are interested in stokers write for our catalogue and full information.

WILKINSON MANUFACTURING CO.

BRIDGEPORT, MONTGOMERY COUNTY, PA.

The New England Roller Grate

NEARLY 6000 SETS IN USE IN NEW ENGLAND ALONE

THIS GRATE will burn any kind of coal and all of it. It has more air space than any other grate and is the only grate that does not change its opening when you shake it. It rests on rollers: is easy to shake: removes the ashes without distubring the surface and does not drop coal into ash pit.

Made in all sizes, for all types of boilers and is easily installed without changing fire box or cutting away of boiler front. It costs practically nothing for repairs and it must and does save fuel.

CATALOGUE AND FURTHER INFORMATION FOR THE ASKING

We also manufacture Shaking and Dumping Grates, either round or square, and a new type of Stationary Grate Bars which may interest you.

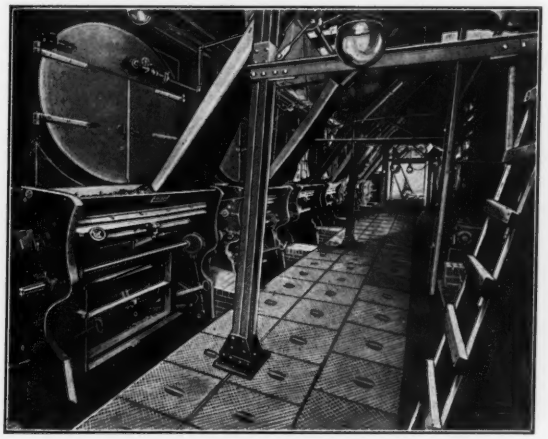
New England Roller Grate Co.

310 Main St., Springfield, Mass.

J. B. HACKETT, Temple Court Building, New York.
WILFONG & WILTBANK, Mutual Life Building, Phila., Pa.

SAVED THEIR COST

In every plant in which Wetzel Mechanical Stokers have been installed they have quickly saved their entire first cost. They will increase the capacity of your plant and protect your boilers from cold drafts.



WETZEL MECHANICAL STOKERS

improve the appearance of your boiler room, eliminate smoke, saves labor, fuel, repairs and shut-downs.

Write for Catalogue and Complete Information.

THE WETZEL MECHANICAL STOKER CO.

147 East State Street, Trenton, N. J.

FOSTER

Piston Actuated Pump Governor

Foster Piston Actuated Pump Governor

is controlled solely by the discharged pressure from the pump and is unique in several important features. Noiseless in operation it is guaranteed to give better, closer and longer continuance in service than any other piston actuated pump governor in the market.

Ask us about Foster "Class W" High Pressure Regulator Free Exhaust Valve, Non-Return Stop Valve, Low Pressure Valves, Back Pressure Valves, etc.

Foster Engineering Co.

NEWARK, N. J.

IMPROVED

Kellam Damper Regulators

THE SIMPLEST AND CLOSEST DAMPER REGULATOR

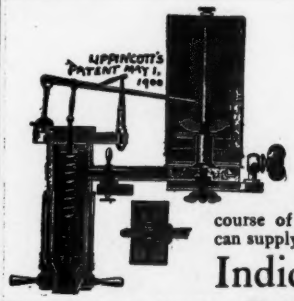
Manufactured by

J. E. LONERGAN & CO.

211 RACE ST., - PHILA, PA.

Brass Founders and Finishers and Makers of Pop Safety Valves, Water Relief Valves, Oil Cups and Lubricators, Steam Pressure Regulators and other Safety Steam Appliances.

Old Kellam Regulators Repaired. Correspondence Solicited. Mention this paper if your inquiry is prompted by the sight of this advertisement. Catalogue D free on application.



I Can Teach You The Indicator

and in connection with the thorough course of instruction which is given by mail, I can supply you with a fine

Indicator Free of all further expense.

If you want an **Indicator, Reducing Wheel or Planimeter,** don't fail to write me and in addition to the fine catalogue, you will receive a neat premium which you will find useful.

Address A. C. LIPPINCOTT, Gen'l. Manager

Green and Columbia Sts. NEWARK, N. J.

Palmetto Twist

The beauty of

Palmetto Twist

is that it can be unstranded to suit the size of the rod or valve stem you want to pack.

Every strand is a perfect packing in itself—just as elastic, well twisted and lubricated as the whole.

A pound spool of PALMETTO TWIST on hand means that you have ready for use packing suited to any small rod or valve in the plant.

PALMETTO TWIST never chars, becomes hard or scores a rod or stem.

Sample spool sent FREE.

Greene-Tweed & Co.

109 Duane St., New York

Climax FORCE FEED Lubricator

WITH SIGHT-FEED—Patented

RADICALLY differs from all others and LEADS all

IT IS MOST POSITIVE because it has a slow suction and quick stroke

IT IS MOST ACCESSIBLE because it has outside valves

IT WILL LAST YEARS

IT HAS A PERFECT SIGHT FEED

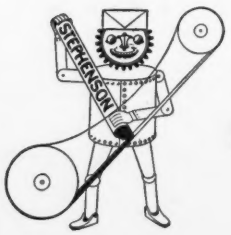
CATALOGUE will tell you why it is better than any other

Climax Lubricator Co.
3 Appleton St., Boston, Mass.

Philadelphia Representative
L. BANCROFT MELLOR
14 S. Fourth Street, Philadelphia

"FORCE-FEED is the only positive lubrication"

NO SLIP



NO SLOP

STEPHENSON
Bar Belt Dressing

Appeals to a man's common sense.

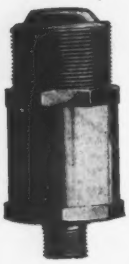
Proves its worth every time it is tried on a slipping belt.

Call on your dealer, or send us 2 Cents for testing Sample, stating if for Leather or Rubber Belts. No ONE kind is good for ALL belts.

Stephenson Mfg. Co.
ALBANY, N. Y.

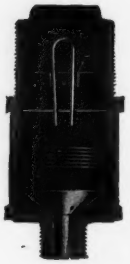
The "PHILADELPHIA" GREASE CUP

Automatic application of grease to the bearings without the use of spring compression.

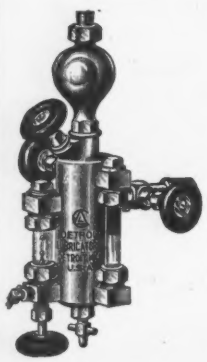


Nature supplies the Feeding Force in the Form of Compressed Air.

Delegates and visitors at the N. A. S. E. National Convention in Philadelphia this month, are cordially invited to call at our exhibit booth. It will be our pleasure to explain the advantages and superiority of our system; to distribute —in convenient printed form—valuable information on lubrication, and to present a souvenir worthy the occasion.



The Philadelphia Lubricator & Mfg. Co., Inc.
1525 Land Title Building, - - Philadelphia, Pa.



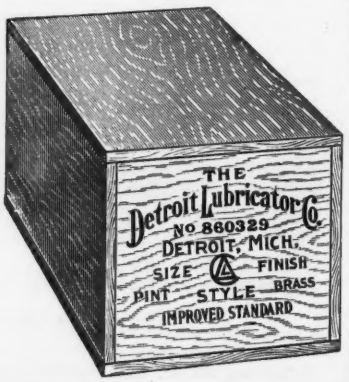
The Detroit Lubricators

Are Standard the world over.

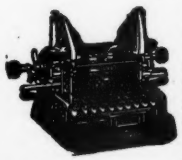
More than 850,000 of them are in use.

Look for the GENUINE ORIGINAL PACKAGE. Catalogue on Application.

Detroit Lubricator Co.
DETROIT, MICH.



YOU CAN EASILY OPERATE THIS TYPEWRITER YOURSELF



Don't worry your correspondent.

Don't write him anything by hand that akes him time to make out—that may leave him in doubt—that he can't easily read.

And don't fil out ega. papers or card memos—or make out accounts in your own handwriting.

It looks bad, reflects on your standing, makes people think you can't afford a stenographer, and is sometimes ambiguous.

You can write out your letters—make out an abstract—fill in an insurance policy—enter your card memos—make out your accounts, or a hotel menu—or do any kind of writing you need, on any kind, size or thickness of paper and space any way you wan on

The OLIVER Typewriter

***The* Standard Visible Writer**

You can write any of these things yourself if you do not happen to have a stenographer.

For you can easily learn with a little practice, to write just as rapidly and as perfectly, as an expert operator on the OLIVER. Because the OLIVER is the simplified typewriter. And you can see every word you write. About 80 per cent. more durable than any other typewriter, because it has about 80 per cent. less wearing points than most other typewriters.

Eighty per cent. easier to write with than these other complicated, intricate machines that require "humoring"—technical knowledge—long practice and special skill to operate.

Than machines which cannot be adjusted to any special space—with which it is impossible to write abstracts, insurance policies, or odd-size documents except you buy expensive special attachments requiring experts to operate.

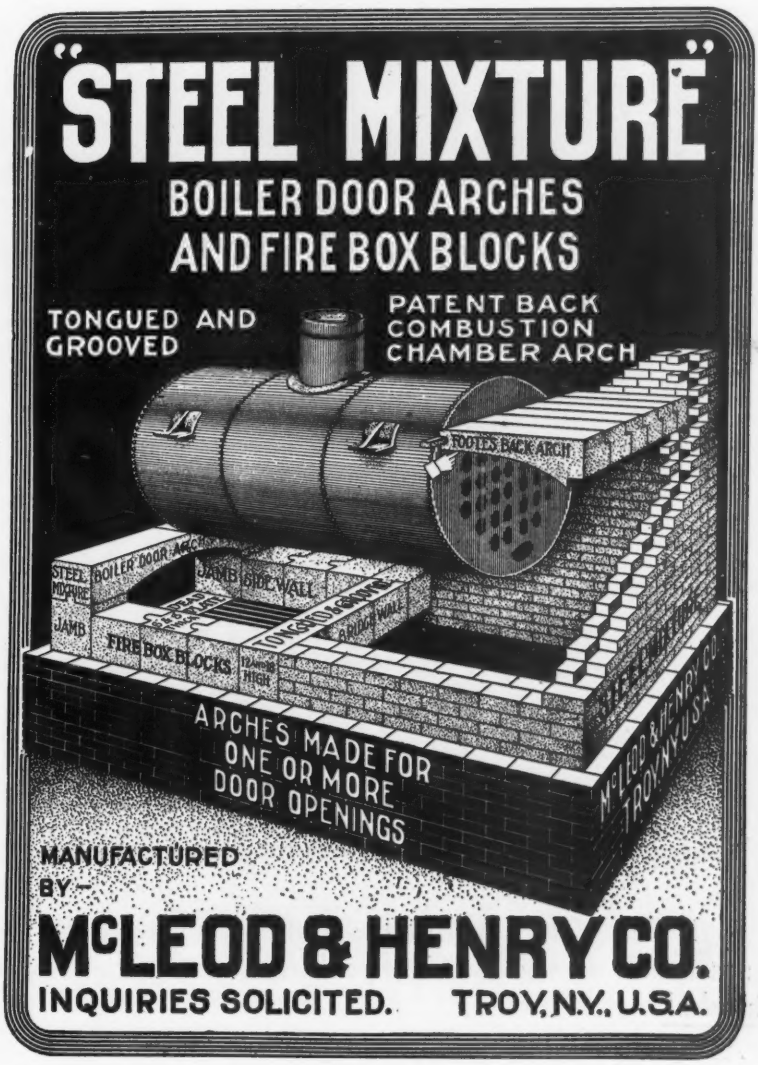
You can adjust the OLIVER to any reasonable space—you can write on any reasonable size and thickness of paper, right out to the very edge, without the aid of any expensive attachment or special skill, and your work will be neat appearing, legible and clear

Forth e OLIVER is the typewriter for the doctor, the awyer, the insurance agent, the merchant, the hotel proprietor—or any man who does his own writing.

Write us now for our booklet on the simplified features of the OLIVER.

***The* OLIVER Typewriter Co.**
WALNUT AND TENTH STS.
PHILADELPHIA, PA.

"STEEL MIXTURE"
BOILER DOOR ARCHES AND FIRE BOX BLOCKS



MANUFACTURED BY—

McLEOD & HENRY CO.

INQUIRIES SOLICITED. TROY, N.Y., U.S.A.

BRANCH OFFICE:—
JOHN H. FOOTE, Manager
1402 BROADWAY—ROOM 1125—KNICKERBOCKER BUILDING—NEW YORK CITY

Walsh Metal Face Packing

A—Fibrous Packing. **B**—Metal.
C—Open space to avoid butting when cover is worn off.
D—Section of metal cut out at C.

Walsh Combination Gaskets

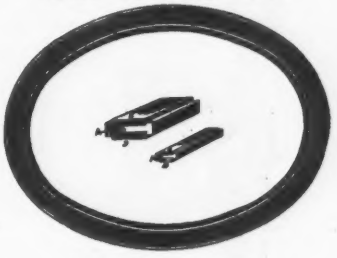
Adapted to all kinds of Steam and Water Packing. Will not cut Rods, will not wear rods to shoulder, will not harden under compression. More durable than fibrous packing. Less friction, as it is lubricant of itself. For packing engines, steam hammers, cranes, valves, expansion joints, pumps, elevators, accumulators, hot-water plunger pumps, etc. **Cotton, Linen and Square Flax Packing in Stock.**

PACKING FOR ELEVATORS a Specialty

Walsh Packing Co.

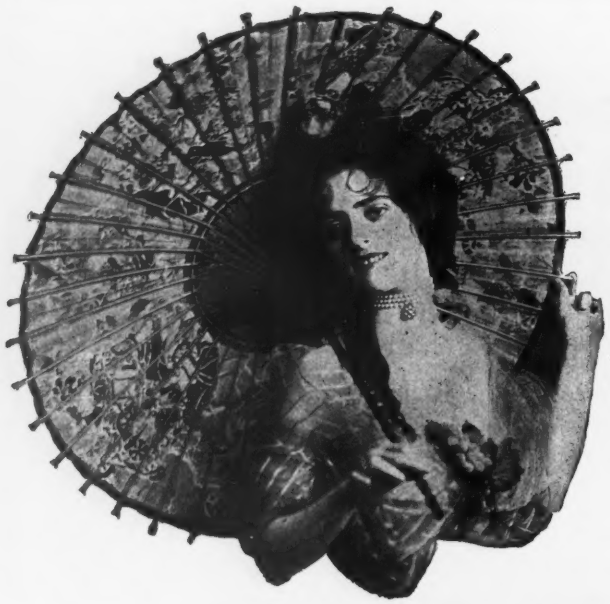
1118 and 1120 S. Seventh St., Philadelphia, Pa.

WILL NOT BLOW OUT



Can be used from 10 to 40 times.
The Cheapest Gasket Made.

A—Soft Metal. **BB**—Rainbow Rubber. Composed of Soft Metal and Rainbow Rubber as shown in cut. Made different widths and thicknesses for man and hand hole Gaskets.



MOUNTED inside the cover of every box of Eureka Gum Core, Eureka Square Flax, Eureka High Pressure, Eureka Water Proof, and Eureka Ammonia Packing will be found for the next three months a photograph 9 inches high reproduced in colors of one of two new "Eureka" Girls. Each makes a very attractive hanger for the walls of your engine room and will serve to remind you that there are now 8 different kinds of

EUREKA PACKINGS

all bearing the red diamond trade mark that only the packing that will stand the test of service in the peerless way old "Eureka" stood it for twenty-five years—can wear.

If you want a gum core packing, a square flax packing, a high pressure packing, an ammonia packing, a ring packing, or a sheet packing—go to your dealer and specify "Eureka" in each case.

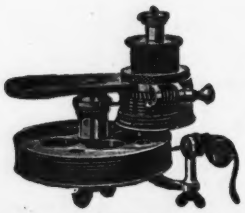
Ask your dealer also for samples of the different kinds of "Eureka" or drop a line to

EUREKA PACKING CO., Sales Dept.
JAS. L. ROBERTSON, Pres.

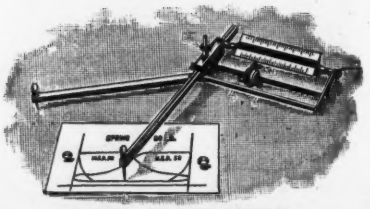
Low cash prices—or very easy terms still hold for Robertson-Thompson Indicators, Willis Planimeters, and Victor Reducing Wheels.

JAS. L. ROBERTSON & SONS
205 FULTON STREET, NEW YORK

Robertson-Thompson Indicator



A Victor Reducing Wheel



The Willis Improved Planimeter

TAURIL SHEET PACKING

IS ABSOLUTELY THE VERY BEST SHEET PACKING IN THE WORLD

TAURIL has a tensile strength of over THREE TONS to the square inch. It will withstand a compressive strain of over FOURTEEN TONS and still retain its elasticity.

It will not burn, blow or squeeze out. It is not affected by steam temperature of 672 degrees fahrenheit.

It is equally well adapted for steam, water, air, ammonia, acids, gases, motor car joints and all kinds of gas engine work at the very highest temperatures and pressures in use.

It does not solidify and cake, which is the primary cause of most joints blowing out, but retains its elasticity under all conditions and will therefore withstand increased strains under varying temperatures.

Joints may be opened as often as desired and same gaskets used over and over again.

It is especially well adapted for long steam lines to auxiliary machinery subject to condensation, water hammering and unequal expansion.

These facts were derived from exhaustive tests in actual practice and are fully guaranteed by

WRITE FOR CATALOGUE AND PRICES.

The GARLOCK PACKING CO.

Main Office:— Palmyra, N. Y., U. S. A.

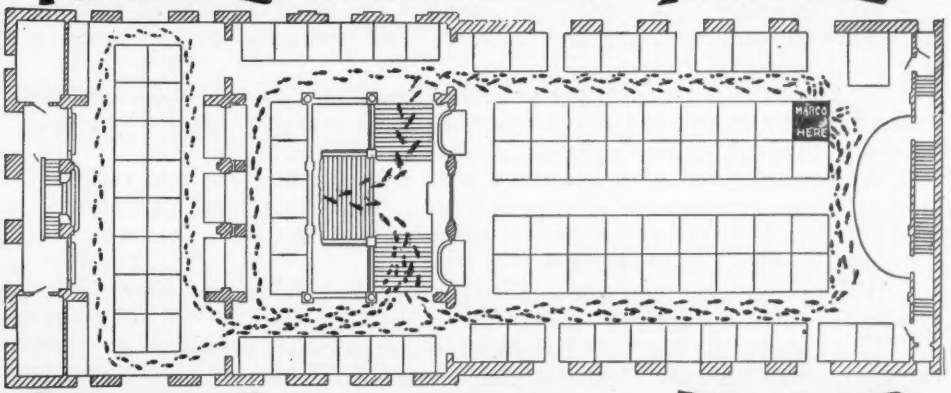
FACTORIES

Palmyra, N. Y. Denver, Colo. San Francisco, Cal.
Atlanta, Ga. Hamburg, Germany

STORES

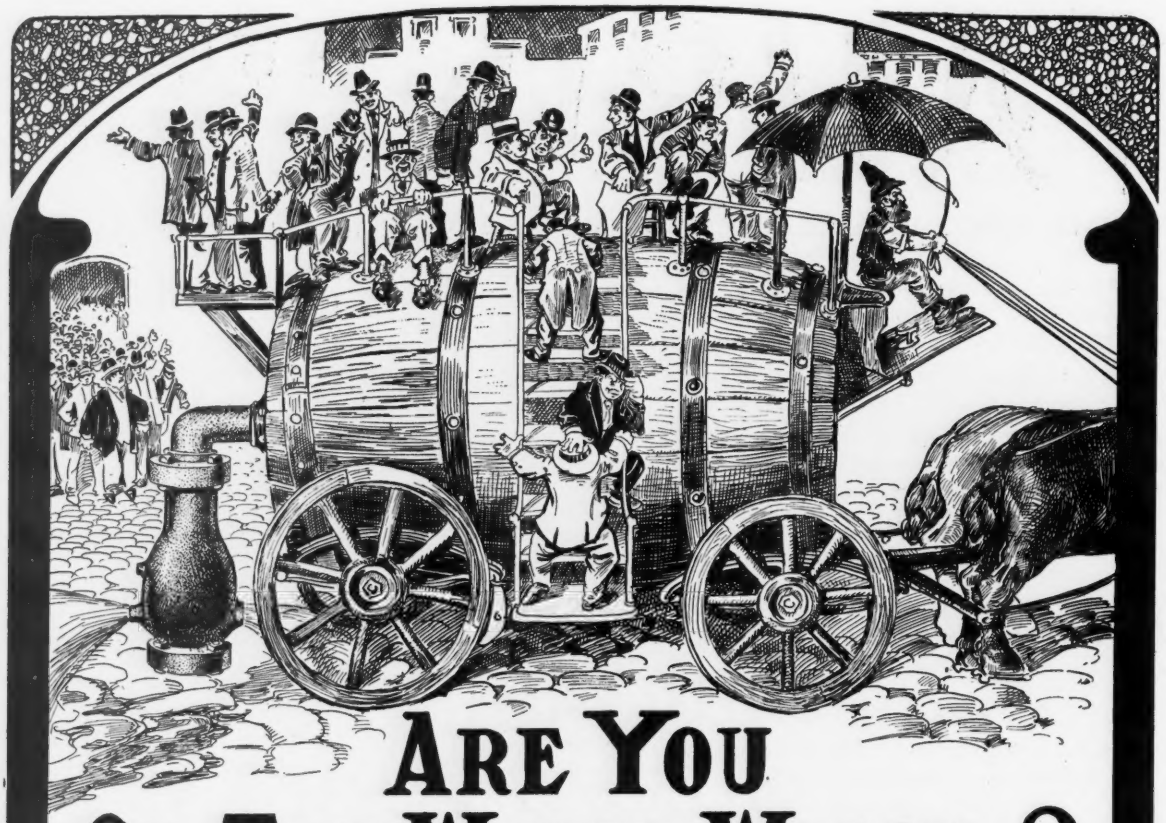
Philadelphia St. Louis New York Atlanta, Ga.
Cleveland Denver Chicago Palmyra, N.Y. Pittsburg
San Francisco Boston Hamburg, Germany

At the N.A.S.E. CONVENTION
MARCO PACKINGS MARCO



MARCO PACKINGS MARCO

THE CLEVELAND RUBBER WORKS
OF THE MECHANICAL RUBBER CO.
74 LISBON ST.
CLEVELAND, OHIO.



ARE YOU ON THE WATER-WAGON ?

which means, have you sworn off using any other than the

SWARTWOUT Steam VERTICAL Separator

This Separator is not only the simplest and most **Practical** but the most **Economical**—because constant "tinkering" is unnecessary to have it do its work as a good Separator should.

The common sense principle of **Centrifugal Force** is applied to separate the water from the steam, and as the steam is forced into the Separator, the helical worm through which it passes causes absolute separation.

We say what we mean and mean what we say, but we would rather send you some expressions of approval from actual users and incidently send you our descriptive booklet—It will **post** you on what a Separator should do to be a good Separator.

Write now—you won't debate long in deciding in its favor after you know some **Swartwout facts.**

The Swartwout cast iron Exhaust Head is as much in advance of other Exhaust Heads as the Swartwout Separator excels all others. Particulars of Free Test on request.

AGENCIES IN ALL PRINCIPAL CITIES

The Ohio Blower Company

43-47 Michigan Avenue, Cleveland, O.

The Ohio Blower Company Cleveland.

Send particulars of your "Free Trial Offer," also your illustrated catalogue and prices

Name_____

Address_____

State_____

Fill out and return the blank corner

COCHRANE-HEATERS

COCHRANE HEATERS

COCHRANE HEATERS

USING a Cochrane Heater is very much like finding a coal mine on your property—with the additional advantage that you do not have to mine the coal in order to earn the dividends

Simply let the exhaust steam do your work of heating water—warming buildings. There are many ways of utilizing exhaust where live steam is now being used, and the work can be just as well done. Thereby you save coal.

Briefly Stated

WHAT YOU OUGHT TO HAVE IS

HOT-SOFT-WATER

for your boilers

We can give it to you—If it is soft we can heat it for you—if it is hard we can heat it and soften it for you.

Holler for help—that is, drop us a line
and we'll send or come

When you attend the N. A. S. E. Convention at Philadelphia, be sure to get a copy of our latest catalogue from the engineer in charge of our exhibit.

Harrison Safety Boiler Works

3144 North 17th Street **Philadelphia, Pa.**

NEED SEPARATORS? WE MAKE THE "COCHRANES"

There Are Reasons For It.

The Patterson-Berryman Feed Water Heater and Purifier

AND

The Patterson Belt Pump

are sold on trial with the distinct understanding that they may be returned to us at our expense should either prove unsatisfactory. *Because*

They are manufactured of the best material and workmanship.

Their efficiency and durability is the highest.

They are simple in construction reducing repairs to the minimum.

If you are interested we would like to explain whys and wherefores.

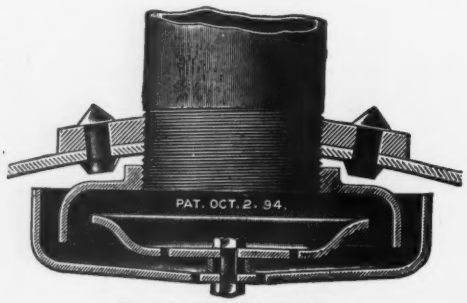
Frank L. Patterson & Co.
24 Cortlandt Street,
NEW YORK

THERE ARE MORE

Compound Separators

used in boilers than all others.

They insure dry steam, and protect your engine from water.



Compound Separator

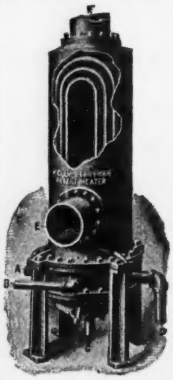
Boiler Fronts, Grate Bars, Furnace Castings, Compound Separators, and General Boiler Castings

The Kutztown Foundry and Machine Co.

WORKS:

KUTZTOWN, PENNA.

Philadelphia Office: Fidelity Building, Broad above Arch Street.



Berryman

Feed Water Heaters and Purifiers

WATER TUBE AND STEAM TUBE

Cast Iron or Steel Shells. "U" Shaped Seamless Drawn Brass Tubes.

We Build Heaters for every Purpose and Condition

THE KELLEY PATENT

Improved Berryman Water Tube, Feed Water Heater and Purifier

BENJ. F. KELLEY & SON, Makers
120 Liberty Street, NEW YORK

The Baum Separator

Horizontal Style for live Steam or Oil Service.

For Live *and* Exhaust Steam
RESULTS GUARANTEED

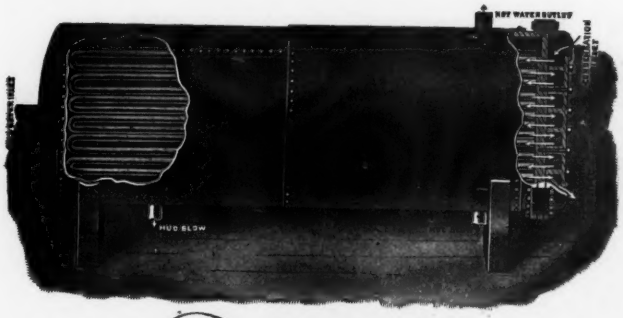
Repeat orders are the best evidence of satisfactory results on the part of a satisfied customer.

"We are using the second Baum Separator and are very much pleased with the results we are getting from it," writes one who has been using Baum Separators for several years.

Write for further information before placing order. A new catalog on request.

Vacuum Style Oil Extractor.

The Baum Separator and Machine Co., MANHEIM, PA.



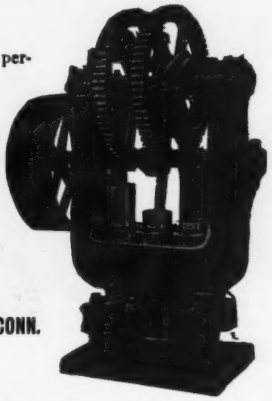
The Gleaner TRADE MARK

The **Gleaner** represents the acme of perfection in feed water heating.

THE

Davis Triplex Power Pump

is a perfect type of the vertical triplex belt driven pump.



MANUFACTURERS OF

The "Berryman" Feed Water Heater and Purifier.

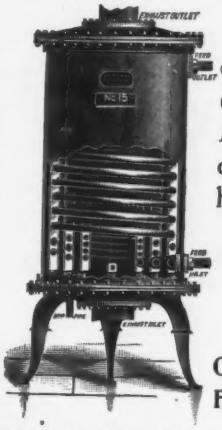
I. B. DAVIS & SON, HARTFORD, CONN.

WRITE FOR CATALOGUE, ETC., TO

THOS. McADOO, 125 N. 4th St., Philadelphia

The National Feed-Water Heater

2,500,000 Horse Power in Daily Use



The principal characteristics of these heaters are *Simplicity, Cheapness, Reliability and Effectiveness,* and full amount of heating surface in every heater.

Supplies Water to the Boiler at 212° F.

We manufacture the **Original and Only Genuine First-Class Coil Feed-Water Heaters.**

We Also Manufacture All Kinds of Coils in Iron, Brass and Copper Pipe

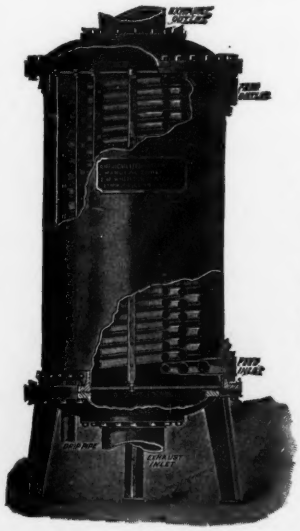
Catalogue and Prices on Application.

Manufactured and Sold Only by

THE NATIONAL PIPE-BENDING CO.

157 Lloyd St. NEW HAVEN CONN.

The American Standard Copper Coil Feed Water Heater



Simplicity!
Strength!
Economy!
A Money Saver!

It gives so little trouble that one of our customers, who has used one for three years, had forgotten that he had it when we asked him the other day how it was doing. He called in the engineer, who said it hadn't been touched since it was put in and was still heating the water to 210 degrees.

THAT.S THE KIND OF A HEATER YOU WANT.

Write for Catalogue No. 100 P

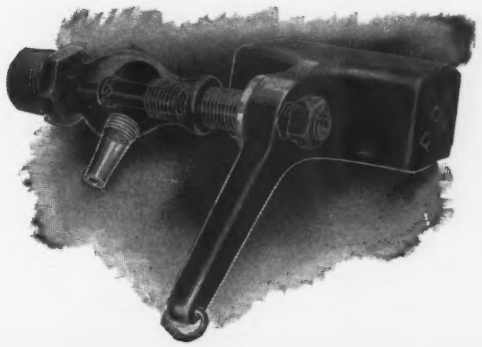
The Whitlock Coil Pipe Co.

HARTFORD CONNECTICUT

GET ONE FREE

Put it on your boiler, and give it a good trial for a month; if it gives you absolute satisfaction, keep it, and pay for it, otherwise send it back at our expense.

"P. B. H." WEIGHT GAUGE COCK

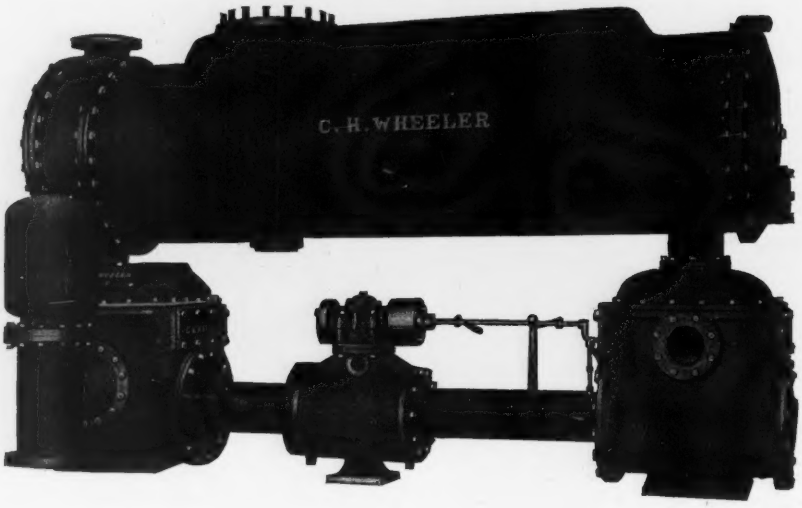


There is but ONE renewable part; the special metal valve pencil, which lasts for years and can be replaced for a few cents, in a minutes time. Thousands in use. Absolute satisfaction on high pressures.

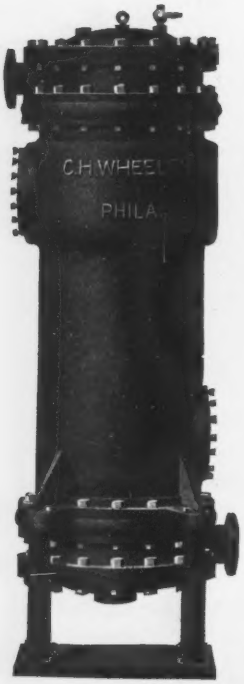
THE PAUL B. HUYETTE CO., Inc. 1245 BETZ BUILDING PHILADELPHIA

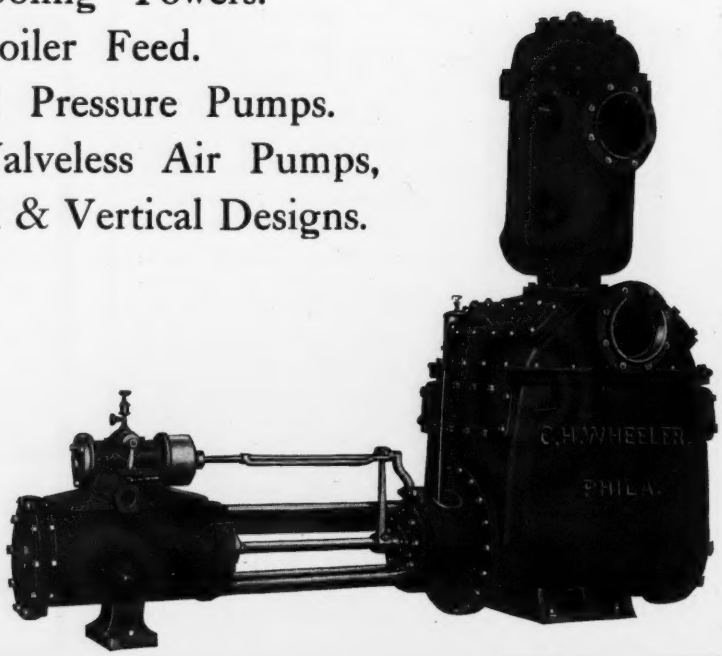
C. H. Wheeler Manufacturing Co.

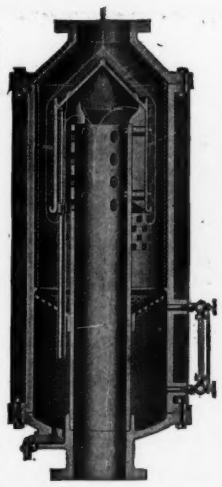
Philadelphia.



Manufacturers of
Surface and Jet Condensers.
Feed Water Heaters.
Water Cooling Towers.
Duplex Boiler Feed.
Tank and Pressure Pumps.
Suction Valveless Air Pumps,
Horizontal & Vertical Designs.







Sweet's Separators

When considering the Separator subject, please let us send our catalog and blue prints; look up the dimensions, weights and proved efficiencies of our machine, compare them with others and see if we don't furnish the most for the money; then consider the **plan** and **finish** of our separators; see if the plan is such that **you think** it will give the results claimed. Made in all styles, for steam or oil.

SEND FOR CATALOG. ALL STYLES.

Direct Separator Co.

220 Marcellus Street

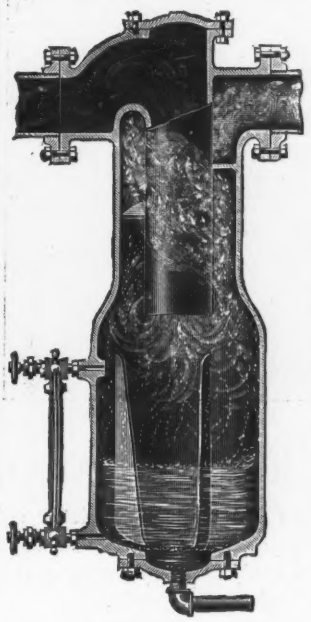
Syracuse : : New York

SALES AGENTS

THE BENJAMIN F. SHAW COMPANY, Wilmington, Del.

THE STRATTON

Steam Separator



Will deliver **Dry Steam** to your engine under any and all conditions, no matter how long your steam pipe or how much your boilers may prime.

Separation takes place by the action of centrifugal force imparted to the steam. The large capacity not only provides for a sudden influx of water but forms a reservoir of steam which equalizes the pressure between boiler and engine, thereby increases the power and stops the vibration of steam pipes; a separator of small capacity is worse than useless, it is harmful.

SEND FOR CATALOGUE

The Goubert Mfg. Co.

85 Liberty Street, NEW YORK

WORKS BAYONNE, N. J.

JAMES GEMMEL

Phones:—Bell, Market, 11-73 D Keystone, Main, 46-91 D

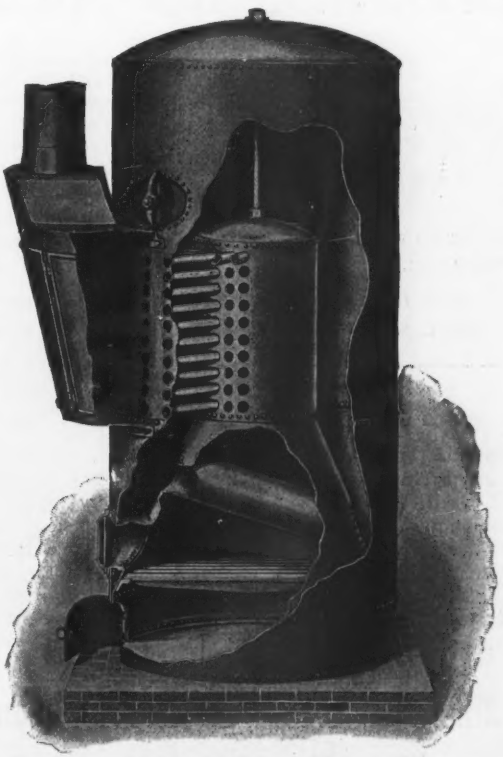
THE GEMMEL PATENT BOILER

This Vertical Boiler possesses all the advantages of a Horizontal Boiler and none of its expensive disadvantages.

It requires only small floor space. It requires no expensive setting. It affords a natural path for the flue gases, and is a rapid steamer.

Its improved construction guarantees rapid circulation, and the highest degree of efficiency.

WRITE FOR ILLUSTRATED CIRCULAR AND PRICES



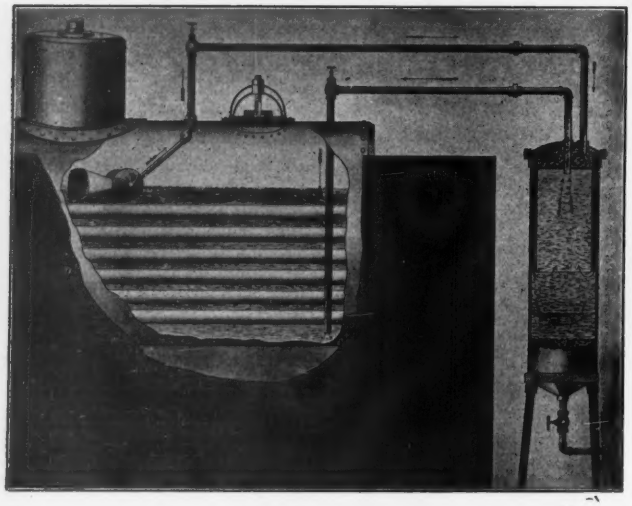
General Engineering Co.

764 Swanson St., Philadelphia, Pa.

ENGINEERS. BOILER MAKERS.

MACHINE BLACKSMITHING.

Machinery Repairs—Cylinders of Engines and Pumps Rebored in place. Stacks, Tanks and all kinds of Boiler Work.



Don't Puncture Don't Poison

Why permit scale to accumulate in your boiler and waste tons and tons of coal driving heat through it, and then puncture the tubes trying to take it out with an expensive mechanical hammering machine? Or why continue to buy barrel after barrel of chemicals — some of which are injurious and positively dangerous to use?

The Buckeye Automatic Boiler Skimmer

will keep your boiler clean and free from scale or sediment without chemicals or other assistance. It is absolutely automatic, the skimmer is always floating exactly on the surface, whether the water is high or low, and is therefore always doing its full duty. It is the only floating skimmer on the market and the only known device that will keep steam boilers absolutely clean all the time without chemicals.

WE INSTALL THEM ON TRIAL WRITE FOR CATALOGUE

THE BUCKEYE BOILER SKIMMER CO., COLBURN AVENUE, TOLEDO, OHIO

STARRETT

Speed Indicator No. 104

Price, Postpaid, $1.00

This Indicator may be run at highest speed required, without heating. The working parts are encased. Dial has two rows of figures, reading either right or left as shaft may run. Steel pointed spindle with rubber tips for both pointed and centered shafts. The O mark may be instantly set at the starting point.

Send for free Catalogue No. 17 N of Fine Tools

THE L. S. STARRETT CO., ATHOL MASS. ,U. S. A.

ENGINEERING

offers the broadest field of development to the ambitious young man. Our courses in Civil Engineering, Mechanical and Electrical Engineering fit you for the very highest paid position in the world. Will you take the first step? Simply clip this advestisement, mail it to-day, and receive **free** our 200 page hand-book describing our 60 courses in Engineering work, including **Electrical, Mechanical, Civil and Structural Engineering, Architectural and Mechanical Drawing, etc. It is worth while**

Do not delay but write now

American School of Correspondence

CHICAGO, ILL.

PRACTICAL ENGINEER,—Sept.

U.S. Automatic Injector

IN THE MIND OF "UNCLE SAM"

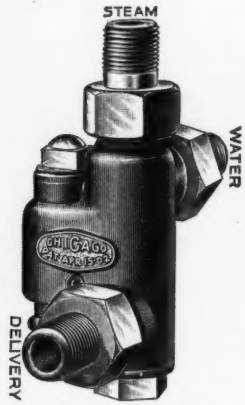
the U. S. Automatic is the World's best injector. It is officially endorsed by the U. S. Government because of superior merit.

The **U. S. Automatic** feeds hotter water than any other injector and works equally well as a lifting or non-lifting injector Never freezes, easily cleaned and always reliable. Saves fuel water and worry—100 per cent efficiency.

Each one is tested before leaving factory and actual results shown on the Certificate of Range and Capacity attached to it. Business prudence demands that you buy the U. S. Automatic.

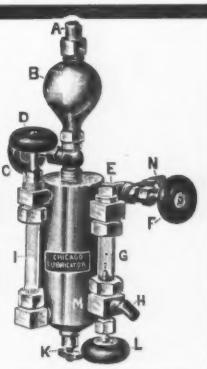
FREE. Let us send you a copy of our famous **"Engineer's Red Book"**—free on request.

American Injector Co., Detroit, U. S. A.



CHICAGO AUTOMATIC INJECTOR

CHICAGO
Injectors and Lubricators



CHICAGO LUBRICATOR

are especially designed for severe service. The UNITED STATES Government having placed a large order for

Chicago Injectors and Chicago Lubricators

for the Panama Canal. This is a strong recommendation for the CHICAGO.

Besides over 150 of the principal Railroads endorse our goods, using our Injectors and Lubricators on their locomotives.

WOULD YOU LIKE TO KNOW MORE ABOUT THEM? ASK YOUR DEALER

OUR 68 PAGE CATALOGUE IS FREE

We also manufacture the Garfield Double Jet Injectors, Garfield Ejectors, Grease Cups, Oil Cups, Cylinder Lubricators, etc.

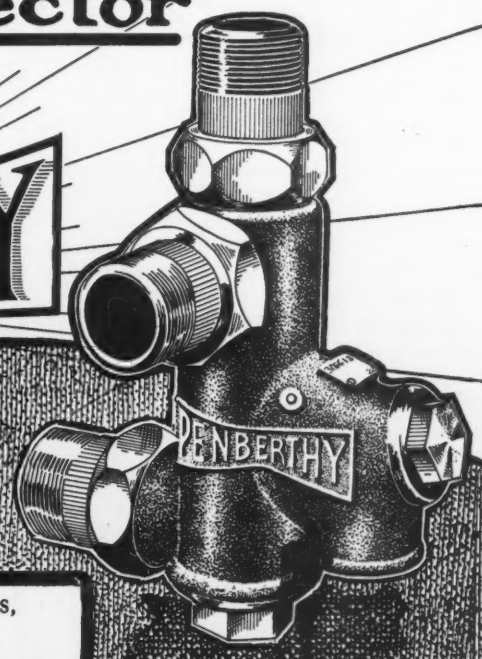
THE OHIO INJECTOR COMPANY

LARGEST MANUFACTURERS OF INJECTORS IN THE UNITED STATES

2128 MAIN STREET - - - - - - WADSWORTH, OHIO

The Sun Never Sets on the Penberthy Injector

TRADE PENBERTHY MARK



SEND FOR CATALOGUE OF INJECTORS, OILERS, ETC.

PENBERTHY INJECTOR CO.

Branch; N. Y. CITY Detroit, Mich.

This Barrel of Philadelphia Grease Must Pay for Itself Before You Pay us a Penny

WE want to send you a full barrel of Philadelphia Grease freight prepaid without any obligation on your part to buy it unless you want to do so.

Then we will also send you EIGHT BRASS GREASE CUPS suitable for your engines or other machinery for which we make no charge.

That's our plan—our new plan of selling Philadelphia grease.

Now, we don't say "Send us your order for a barrel and if not satisfactory we will refund your money." That is not our way. You might feel that there was some doubt about getting your money back if you wanted it, and we don't want you to feel that way.

SIMPLY DO THIS write us a letter and tell us the H. P. of your engine, the R. P. M. and state where the cups are to be placed, giving the size of the tap for each cup. The letter should be on your business stationery and signed by some one in authority.

Then we take all the risk and send you, freight prepaid, a barrel of Philadelphia Grease and eight brass cups.

You see, Philadelphia Grease is so much better than any other grease that we can afford to send it out this way feeling certain that you will want to keep it and that you will become a regular customer.

When you receive the barrel, open it up, apply the cups and use as much of the grease as you want to give it a thorough trial.

When you have tested it three weeks, if you find it the best lubricant you ever used, better than any oil at any price and far better than any other grease, keep it. But you don't need to pay for it even then for we give you six months' credit—that's our new plan.

You see Philadelphia Grease will last so much longer than oil or any other grease that it very soon saves the entire cost of the whole barrel.

We figure, that even in a very small plant it will more than save its cost in six months so that you do not have to pay us until it has had time to save its cost. In that way we make the oil man or the other grease maker buy it for you.

If the grease does not prove to be the best lubricant that you ever used and if you are not entirely satisfied with it after a three weeks' test ship it back at our expense, also the cups, and you owe us nothing for what you have used in testing it.

Did you ever hear of anything as clever as this in the grease line?

It's this way—the reason we can make this offer is because we are not in the least doubtful about our grease, we have been making it for years, and we know that it has no equal as a lubricant for engines, and machinery of all kinds.

We do not claim that PHILADELPHIA GREASE is "just as good as some other grease." We do not even claim that it is "just as good as the best." What we do claim is that it is better than any other grease ever offered to the power using public, and we are proving it every day in actual working tests under every possible condition of power plant service in hundreds of the largest power stations and industrial plants of the world.

Philadelphia Grease is a highly refined lubricant made by an improved dry heat process from a special combination of the best quality of oils. It has a fine, close, even grain and a rich natural color which distinguishes it instantly from inferior greases. It is pure enough to lubricate a watch and cheap enough to use on any kind of machinery or line shafting.

It is not affected by changes of temperature, it works just the same in cold or hot climates.

It will keep for years if desired, and grows better with age.

And because of all this—we can afford—and are glad to send a full barrel of Philadelphia Grease, freight prepaid, to any owner of engines or other machinery, without any conditions, except that it be shipped back to us, also the cups, at our expense if not satisfactory after three weeks' trial.

You will owe us nothing for what you use in testing it.

Now—write us to-day giving us the H. P. of your engines, approximate speed and size of taps for cups. We must know these things so that we will know whether to send you a heavy or light density—it is all the same high quality.

Our special low price for the first trial barrel is 15 cents a pound. Not more than one barrel to the same purchaser at this price.

The eight brass cups are given absolutely free with your first purchase of a barrel.

Remember, you have three weeks' free trial—then either keep it and pay us in six months or return it at our expense.

The Philadelphia Grease Mfg. Co., BOURSE BLDG., PHILADELPHIA
97 HIGH STREET, BOSTON, MASS.

ELEVATOR REPAIRS

YOU HAVE ELEVATOR TROUBLES. WE HAVE EXPERIENCE. LET'S SWAP.

Keystone Elevator Inspection & Repair Co.

923 LOCUST STREET, PHILADELPHIA

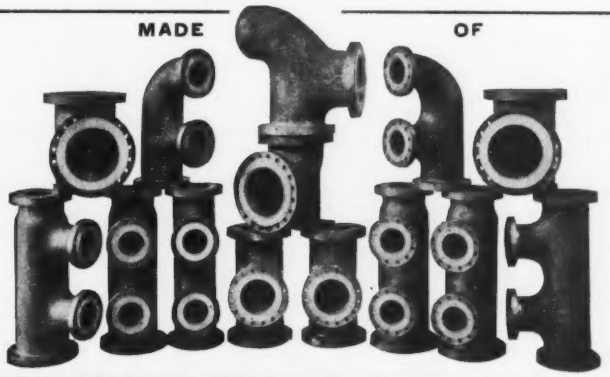
BELL PHONE—FILBERT 2258 KEYSTONE PHONE—MAIN 10-06

High Pressure Fittings

We furnish these fittings complete, including all drilling facing etc.

BIRDSBORO STEEL FOUNDRY AND MACHINE CO.

MADE OF



O. H. Steel Castings

All castings tested to 1000 lbs. hydraulic pressure if desired.

BIRDSBORO, PA.

DO YOU WANT TO MAKE MONEY?

NO HOT AIR. NO HOLES IN THE GROUND.

A few shares of the stock of a company for sale at par, $1.00 which will enable you to participate in the profits derived from the handling of a number of inventions.

WRITE FOR INFORMATION

INDUSTRIAL ENGINEERING CO.

805 Provident Building, Philadelphia, Pa.

DO YOU LUBRICATE WITH GREASE?

You will find the **"POWELL" Grease Cups** a boon for lubricating your Engines. The flow is controlled by cut-off in hexagon of shank. Can be operated from either side by means of a screw driver and the adjustment so regulated as to feed the grease only as fast as consumed thus preventing all waste.

Our "BRUNO" all iron Cup is used for bearings and journals where finish is not essential.

Our "RENOWN" all brass either polished or plated, for all parts of your Engine **except steam chest.**

Send for circular describing our various styles.

***The* Wm. Powell Co., Cincinnati, O.**

Phila. Depot, 518 Arch St. New York Depot. 51 Cliff St.
Boston Depot, Cor. High & Congress Sts.

YOUR Declaration of Independence

Everybody knows what the stroke of a pen did for this great nation.

Do you realize what the stroke of a pen or pencil will do for you?

The coupon shown below is the wage earners' declaration of independence. Signed and sent to the I. C. S., it brings, without further obligation to you, practical advice and explanation of how that wonderful institution, the INTERNATIONAL CORRESPONDENCE SCHOOLS, that have enabled 100,000 men and women to advance from low-waged jobs to high-salaried positions, can help **YOU** to better your position and increase your earnings without losing an hour of work or a dollar of pay, or paying more than your present income will afford, no matter how small it is. We fit our plan to your own individual case and needs in a way that makes success for you certain. Do you wish for freedom from overwork and underpay? **Then sign your Declaration of Independence and mail it today.**

International Correspondence Schools
Box 835, Scranton, Pa.

Please explain, without further obligation on my part, how I can qualify for a larger salary in the position before which I have marked X.

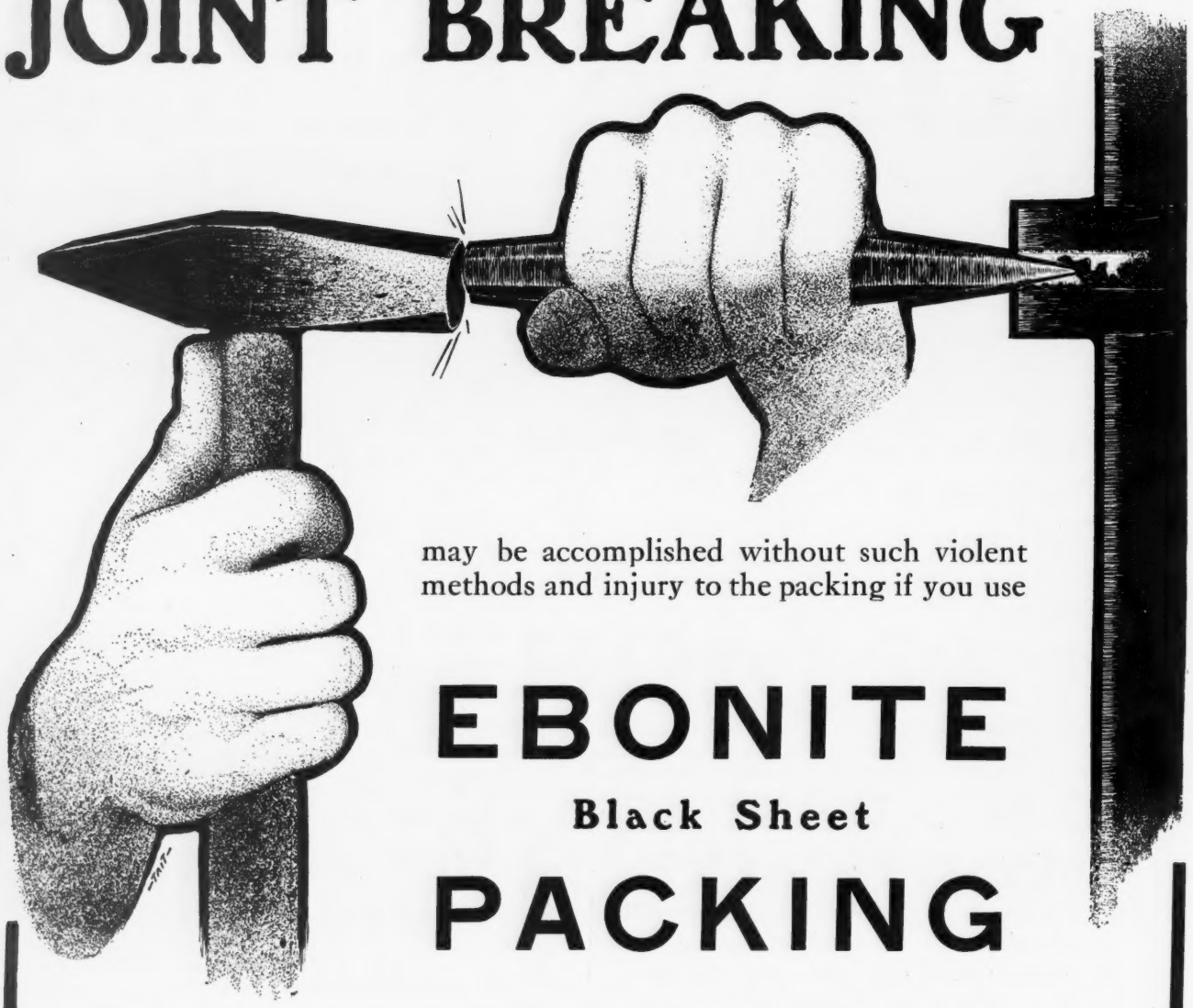
Mechanical Engineer	Marine Engineer
Mechanical Draftsman	Civil Engineer
Machine Designer	Bridge Engineer
Foreman Machinist	Surveyor
Electrical Engineer	Mining Engineer
Chemist	Architect
Sheet-Metal Draft's	Bookkeeper
Electrician	Stenographer
Stationary Engineer	Ad Writer

Name _____

St. & No. _____

City _____ *State* _____

JOINT BREAKING



may be accomplished without such violent methods and injury to the packing if you use

EBONITE

Black Sheet

PACKING

To such a superior degree have we developed this popular Black Sheet Packing that even in a *Superheated* steam joint—the hardest test of a packing—EBONITE will neither solidify nor adhere to the metal.

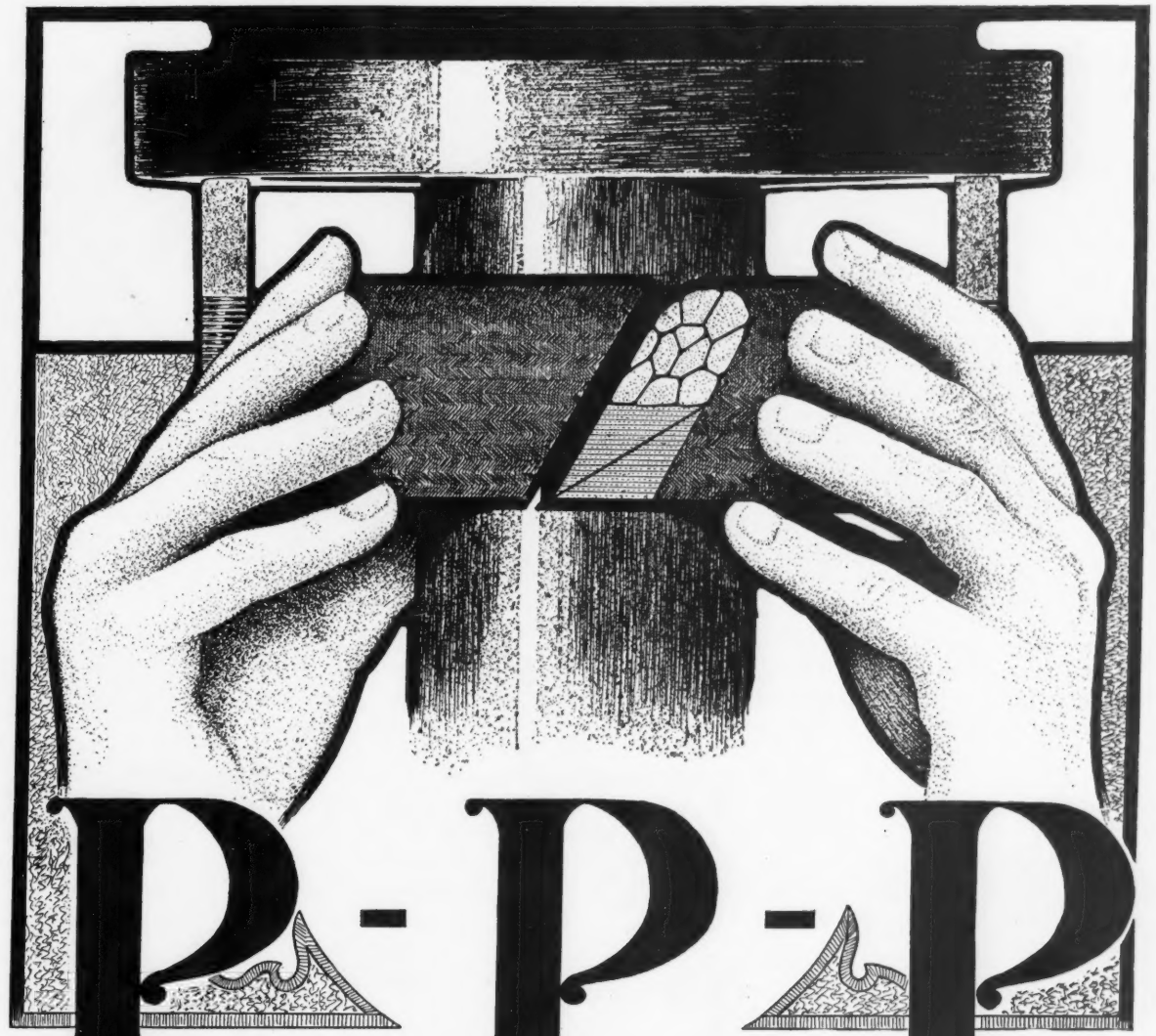
Tests of its tensile strength have proven equally remarkable. It will practically resist any pressure, and when properly applied cannot squeeze or blow out.

For ammonia—acid—gas—water—air—steam—*for any kind of a joint*—EBONITE can be depended upon absolutely! Can you say as much for any other packing?

We are ready to supply you with a sufficient quantity of EBONITE for a test. If it doesn't outlive the packings you think are the best—no charge whatever.

Quaker City Rubber Company

PHILADELPHIA . . . CHICAGO



P-P-P

ROD PACKING

Is Made Especially For You!

We make a size you can use in your engine or pump—however large or small—which will fit the rod like a glove, and conform to any irregularities of the stuffing-box.

Nothing made elsewhere—even to order—would be near as satisfactory, because it couldn't fit any better, and besides you would be out thr **long-life** feature of P. P. P.

P. P. P. is not a cheap packing. It's made, throughout, from the best material, and the best is never cheap.

But if you consider price, just make a note of this: P. P. P. is twice as wide as it is thick—therefore, one ring is equal to two of solid packings. It weighs from twenty to forty per cent. less than solid packings, so that you are certain to gain when you buy by the pound.

Our aim is to have you be the judge. Send us your order, and if, after a fair trial, you can't pronounce P. P. P. the best packing you have ever used, there'll be no charge whatever.

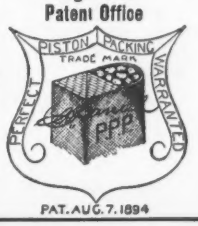
QUAKER CITY RUBBER CO.

PHILADELPHIA—CHICAGO

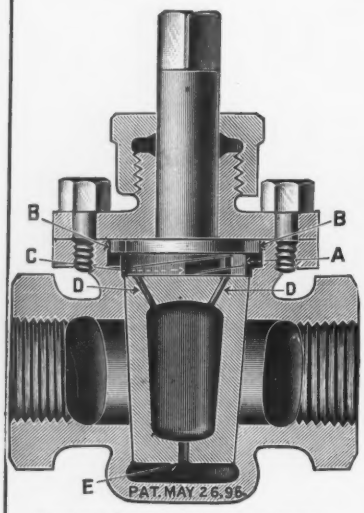
This is the P. P. P. trade mark. It stands for the **original** and **only genuine** self-setting packing.

It is imperative, therefore, that every engineer looking for better results should look for this trade mark.

It is the engineer's guarantee that he is receiving the best fibrous packing in the world—no exceptions whatever.



Use A Homestead Valve Once



Homestead Straight-way Valve.

Money cannot buy a better Valve

and you will never be satisfied with any other. A one-fourth turn opens or closes it. The plug is balanced and held in place by pressure when open. When closed it is locked by the patent wedging cam. There can be no friction and the seats are protected from wear which makes it almost indestructible for blow-off as well as for the highest pressures in air and hydraulics. For years these valves have been used in the immense steel mills of Pittsburg and vicinity where the pressures average higher than in any other district in the world

Homestead Valve Manufacturing Company

Brass Founders

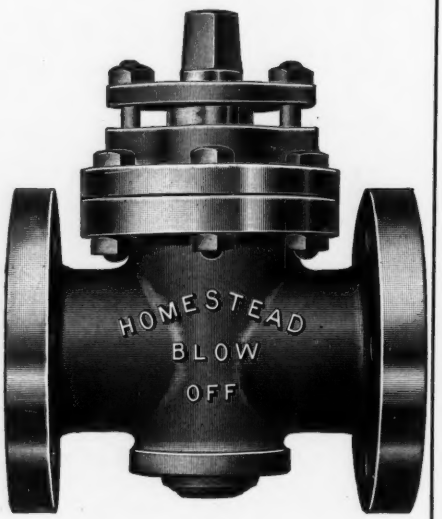
P. O. Box 1754 Pittsburg, Pa.

Works at Homestead, Pa.

Homestead Three-way Valve

Homestead Four-way Valve

OUR CATALOG describes the construction and operation of our entire line. Shall we send it? A postal card gets it.



AGENCIES

E. M. Dart Mfg. Co., Providence, R. I. Brogan & Co., Phila., Pa.
Jos. H. Whitehead & Co., Chicao, Ill. Chas. F. Mitchell, San Francisco Geo. C. Johns, New York
W. A. Case & Son Mfg. Co., Buffalo, N. Y. The F. D. Wallaker Co , Denver, Col.
U. S. Supply Co., Omaha, Neb. Wallace & Gale, Baltimore, Md.
Kansas City Oil and Supply Co., Kansas City, Mo.

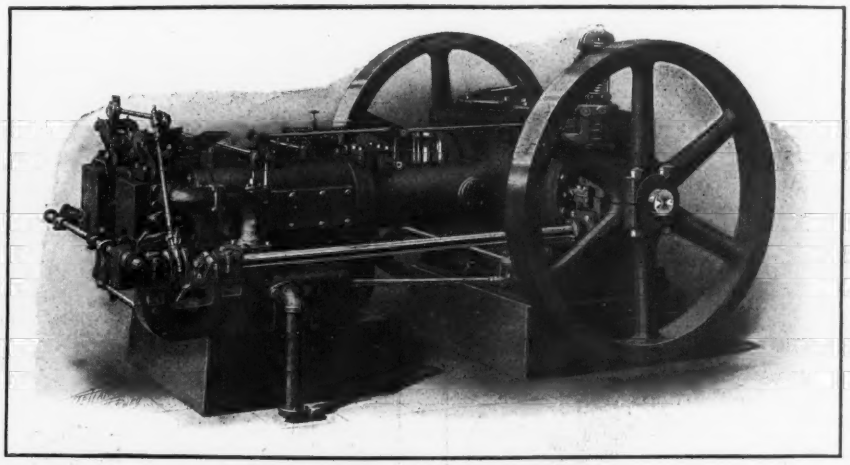
THE BUCKEYE GAS ENGINE

SIMPLE, ECONOMICAL, DURABLE

ESPECIALLY ADAPTED TO DRIVING ELECTRIC GENERATORS

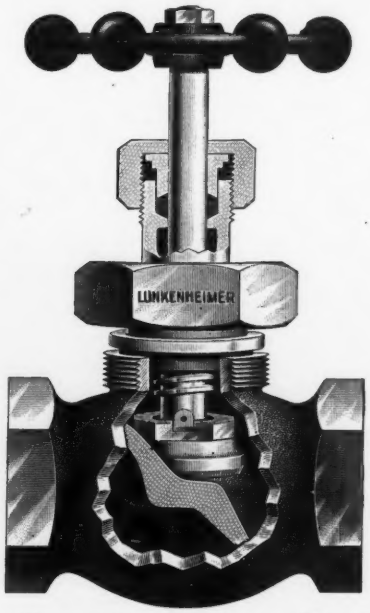
BUILT BY BUCKEYE ENGINE CO., SALEM, OHIO

TYPES	POWERS
SINGLE ACTING TWO-STROKE CYCLE	25 H. P. TO 500 H. P.
DOUBLE ACTING TWO-STROKE CYCLE	500 H. P. TO 6000 H. P.
DOUBLE ACTING FOUR-STROKE CYCLE	500 H. P. TO 6000 H. P.



WE STILL MAINTAIN OUR REPUTATION FOR INDEPENDENT THOUGHT AND ACTION AND FOR KEEPING ABREAST OF THE TIMES, AND IN PRESENTING THE BUCKEYE GAS ENGINE, ENGINEERS AND PURCHASERS WILL NOTE THAT WE ARE ORIGINATORS AND LEADERS IN THIS NEW LINE AS WE ALWAYS HAVE BEEN IN OUR STEAM ENGINE PRACTICE. WE CUT FROM NEW CLOTH.

WRITE US WHEN WANTING EITHER GAS OR STEAM ENGINES.



THE value of an article can be gauged by the number of imitations.

LUNKENHEIMER
Regrinding Valves

are imitated by many, but equalled by none. All genuine valves have the name **Lunkenheimer** cast on the body

If your Local Dealer cannot furnish them, notify us.

The Lunkenheimer Co.

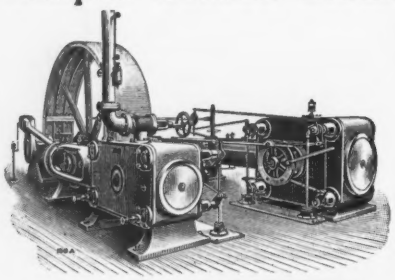
Largest Manufacturers of High-Grade Engineering Specialties in the World.

General Offices & Works CINCINNATI, OHIO, U. S. A.

BRANCHES:—New York, 66-68 Fulton Street.
London, S. E. 35 Great Dover Street.

We manufacture a complete line of iron and brass Globe and Gate Valves, Oil and Grease Cups, Injectors, Water Columns and Gauges, Hydrostatic and Mechanical Lubricators, Ejectors, Cocks, Whistles and Whistle Valves, Pop Safety, Relief and Blow-off Valves, etc.

Eclipse Corliss Steam Engines



Simple, Tandem and Cross Compound—Condensing and Non-Condensing

MAINTENANCE, REGULATION, DURABILITY AND ECONOMY

Fully Guaranteed

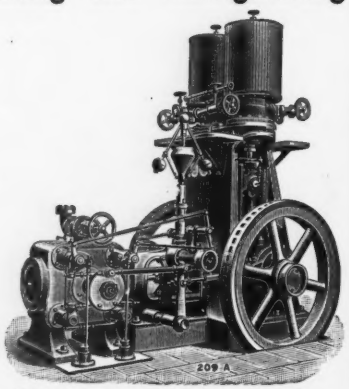
Eclipse Ice-Making and Refrigerating Machinery

THE WORLDS STANDARD

Complete Equipments for Ice Manufacture.

Entire Installation of Mechanical Refrigerating Systems for **PACKING HOUSES, BREWERIES, COLD STORAGE WAREHOUSES**

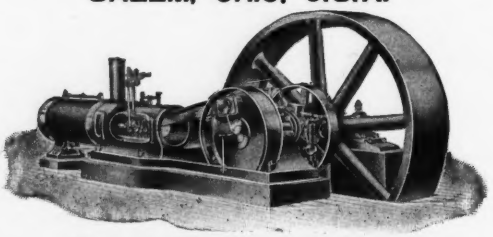
Catalogues Mailed Free on Request



FRICK COMPANY, Waynesboro, Pa., U.S.A.

BUCKEYE ENGINE Co.

SALEM, OHIO, U.S.A.



STEAM ENGINE BUILDERS.

THE LARGEST LINE OF MODERN ENGINE PATTERNS IN THE WORLD.

SEND FOR ILLUSTRATED CATALOGUE.

DAVIDSON PUMPS

"THE BEST PUMP BUILT"

FOR ALL SERVICES

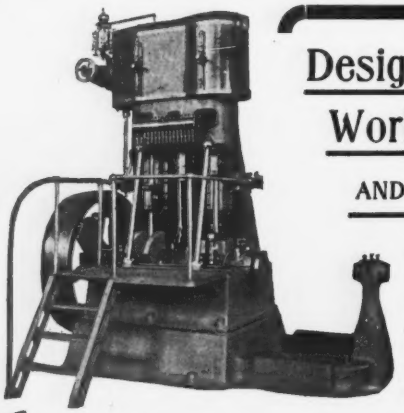
Finest Mechanical Design and Construction

Material and Workmanship first class in every respect.

SEND FOR CATALOGUE

M. T. DAVIDSON 141 Broadway, New York

Boston Office:—30 Oliver Street



Design Workmanship AND Material

are the essentials that count for economy, efficiency and durability in the construction of a steam engine

REEVES ENGINES

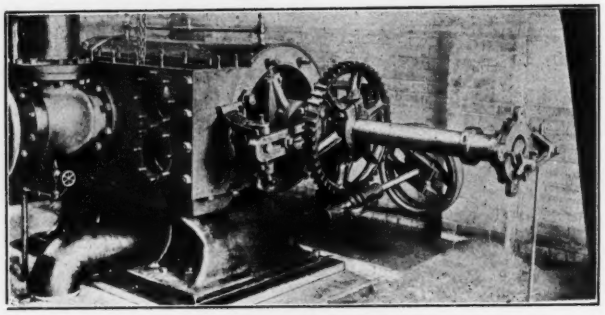
are designed for the highest economy and will develop uniform power with the smallest possible consumption of fuel, lowest cost of lubrication and practically no cost for repairs. A Reeves Engine will never cause a shut down, and they will out-last any ordinary engine by many years. All running parts are protected by and enameled steel shield. Water sufage cannot mix with oil which affords better lubrucation and permits oil to be used over and over.

Sent for catalogue and report of test **The Reeves Engine Co.**

MAIN SALES OFFICE AND WORKS TRENTON, N.J.

Branch Office: W. E. S. Dyer, Manager 2223 Land Title Bldg., Philadelphia, Pa.,

Engine Repairs



LEES' (PATENTED) IMPROVED PORTABLE BORING TOOL IN POSITION.

With Our Improved Methods and Tools we can repair your engine without removing from foundation and Save Hours of Shut-Down

ENGINES ADJUSTED

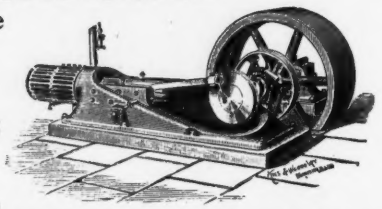
Hartford Engine Works

HARTFORD, CT.

Successors to

Hartford Engineering Company

Builders of the IMPROVED HARTFORD BUCKEYE ENGINES



We have the drawings and patterns and keep a line of repairs finished and part finished on hand for

Hartford, Buckeye, and Woodruff & Beach Engines

Lord's

IN 1865

BOILERS in the year 1865 became filled with scale just as they do to-day. This fact was looked at in a different light then, because what we now know as Industrial Chemistry was then practically unknown.

Of course many engineers in those days had their secrets of getting scale out of a boiler, coming pretty close to the mark sometimes, just as a few do to-day. The majority did more harm than good. Boilers were not very large in 1865, however, and so the amount of harm done was not excessive.

GEO. W. LORD

We mention the year 1865 because it was then that George W. Lord introduced the boiler room to the chemical laboratory. Since then the engineer has taught the chemist a great many valuable facts and the chemist has saved the engineer a great deal of trouble, and his employers, a great deal of money. But all this was not thought of when George W. Lord took the first piece of boiler scale into his own laboratory for analysis.

ENGINEER AND CHEMIST

Mr. Lord was then an engineer. He was also a chemist for the love of the science and did not imagine at first that it could have any particular bearing on his future. After his first analyses were made, and his prescriptions tested and found to work out as well in the boiler room as in the laboratory, he immediately saw the importance of his scientific method of boiler treatment and devoted himself steadfastly to it.

THE PROGRESS IN 41 YEARS

To-day Mr. Lord can review with peculiar satisfaction the progress of the last forty-one years, in the domain of what may be called steam chemistry. The reminiscences of the pioneer are always interesting, but in this case they are hightly important as he has seen the success of his methods followed by a multitude of imitators, many of whom are selling compounds bearing names as similar to Lord's as the alphabet will permit. He has also seen the failure of the heater and the purifier to supplant careful chemical boiler treatment. The time now devoted to the study of boiler room problems in technical schools is peculiarly pleasing

Lord's

to this scientist who long ago, in the face of opposition, perceived the importance of investigating steam difficulties. The results of expert investigations exhibited in endless tables of figures verify the data Mr. Lord collected years ago in his own laboratory. The files of the George W. Lord Co., as well as the personal records of Mr. Lord, are filled with communications addressed to him by members of learned societies all over the world at dates varying from 1865 to the present time. His patient and systematic collecting of the facts in each case which has come to him in the course of these years and his painstaking deductions of general rules from these facts have been referred to repeatedly by experts when highly important questions were at stake.

COMPLEX PROBLEMS

Like all men whose experience has been extraordinary, Mr. Lord speaks modestly concerning his achievements. But a glimpse at the hundreds of letters from the captains of industry and leading engineers of the world expressing their appreciation of the commercial value of his services in their great plants would be a source of envy to many men who consider themselves important. In the last forty-one years, Mr. Lord has seen the boiler room grow from a small room into a great power house. In the developement of the complex problems presented by this marvellous growth he has borne a part far more important than the general public is aware and only because of his modesty; his work is known only to the technical men themselves.

CERTIFICATES OF ANALYSIS

Mr. Lord's life may be said to be centered in his laboratories and works. Each day hundreds of questions are presented for solution. The problem, whatever it may be, is first classified and then passed on to the technical man or head chemist. If it is an ordinary every day question of scale, it is put through a careful analysis by one of the assistants and the results reviewed by the chief himself. At that time the prescription is made out and the directions for use prepared. The report is then returned to the business office for future use. A certificate of analysis, signed by the head chemist, is sent to the engineer presenting the scale or

Lord's

feed water and the price of the chemicals needed is quoted in an accompanying letter.

COSTLY EXPERIMENTS

When however the case presented is a difficult one, quite a different procedure is necessary. First of all, the analysis takes place under the direct eye of the chief, after which the records are carefully studied to learn of similar cases. The matter is then turned over to Mr. Lord himself, and out of his great store of experience a course of action is laid down. It may be necessary for experiments far more costly than the profits of the sale to be undertaken before any prescription dare be made. Scale from the mines of Africa and the plantations of South America and, oddly enough, even from some plant near at home will present difficulties of the most exasperating character. When it is seen that the problem requires for its solution work and chemicals altogether outside of the possibility of business profit, then the scientist in Mr. Lord shows best, for he proceeds steadfastly with the work solely for scientific reasons, recording carefully every minute detail and inspecting the records himself to see that everything down to the slightest point is correct.

WATER

Chemical treatment of the various incrustations that collect in boilers, as well as the corrosion that frequently destroys them, is one of the most interesting studies in Industrial Chemistry. Water itself is apparently a simple thing to handle and yet frequently becomes a highly complex problem.

RAIN WATER

First of all, what we know as chemically pure water, that is water that contains no minerals in solution, is one of the greatest solvents known. Should such water as this enter boilers, it would immediately begin to eat up the iron, so to speak, and in a marvellously short time serious corrosion would follow.

Engineers very properly desire what they call soft water, that is water which contains very little lime. In order to get this they sometimes use rain water. Rain water, it is true, contains no lime but it takes up a great quantity of free carbonic acid from the air. This acid should have with it in the water a certain

Lord's

quantity of minerals in order to prevent its combining with any other substances with which it may come in contact. Rain water of course does not contain any mineral matter, and as a result of this as soon as it is put into the boiler the free carbonic acid begins to attack the iron and pitting is the result. It is necessary therefore to add a certain quantity of mineral matter to rain water before it is safe to use it in a boiler.

SCALE VARIES

If you will ask a chemist who makes a study of water to name the common scale forming ingredients he will tell you that scale varies in different parts of the country. In one section, scale will be composed perhaps of magnesia: in another section, there will be little magnesia but a great deal of calcium sulphate; in another section again, calcium carbonate will be plentiful. If the source of the water is a deep well, probably little organic matter will be present; but if the water is what we call surface water, that is taken from ponds or springs, probably a great deal of decaying vegetable matter will enter the boiler in the feed water, and under the influence of heat break up into organic acids, these attacking the boiler surface and precipitating iron oxide or rust. As a general conclusion it may be stated that boiler scale varies in every part of the United States, and sometimes for no apparent reason it will vary considerably in the same localities.

SPECIAL TREATMENT VERSUS READY MADE

Common sense therefore will confirm the statement of the chemist that each and every case of boiler scale must have special treatment. The chemist will tell you that the re-agents that will remove magnesia will have no effect upon calcium sulphate, and when the more highly complex incrustations are considered, even a school-boy will admit that one ready made mixture cannot possibly be suited to even one tenth of them. Every man, no matter in what business he may be engaged, can see from this statement of facts that the claim of any ready made compound is an absurdity. To imagine that the same substances will clean a boiler in the mines of Colorado and the mills of Pennsylvania shows considerable lack of information on the part of the man making the

Lord's

claim, to say the least. We may also state that the hardest problems handled at our works are those arising from the use of harmful compounds. Frequently the feed water in a Plant will offer no difficulties, but upon examination the boilers will be found to be in such a precarious condition from the use of acids that long and expensive treatment may be necessary to save them.

SODA

Very frequently, engineers make the error of using some one substance such as Soda Ash, Caustic, Kerosene Oil, or Tri-Sodium Phosphate, to clean out the scale without first learning the ingredients of the scale they have in their boilers. For instance, Soda Ash is efficacious for one particular scale forming substance and if this is present in large quantities then the Soda Ash treatment will prove effective, but it is too often the case that money is wasted and boilers are injured by using substances which are worthless under the circumstances. It is absolutely necessary before putting anything in the boiler to learn the chemical construction of the scale, and until that is done nothing can be properly used to treat the scale.

KEROSENE

As to Kerosene Oil; a word on that point may be important. It should never be allowed to enter the boiler at all. It has no chemical action whatever on the scale. It does attack the boiler structure and seriously harms it. Almost invariably the residue of the oil settles as a thick scum on the top of the scale and acts as a non-conductor of heat. It consequently becomes necessary to raise the temperature of the boiler plates to at least five hundred degrees in order to obtain steam. As a result, bagging and bulging and sometimes serious accidents occur.

WATER PURIFYING HEATERS

Our opinion is frequently desired upon the worth of various systems of water softening, water purifying and water heating. A few words about them therefore may be interesting. Generally speaking, their value depends upon the particular circumstances in each case. The principle of the heater is to raise the water to about two hundred degrees at which temperature the carbonates

Lord's

are precipitated. It will be seen from this that if the water contains a great deal of carbonates, the heater will become filled with them and the boiler will be benefited. Right here, however, several difficulties are apt to occur. The heater may be badly situated and it will become practically impossible for the engineer to clean it. The result will be that at great expense the heater will have to be torn apart and perhaps thrown away. Every engineer will understand that it is usually far more convenient to clean scale out of a boiler than out of a heater. Again in almost every case feed water contains sulphates as well as carbonates. The heater has no effect upon the sulphates and consequently they pass over into the boiler and form an extraordinary hard scale. In such a case the engineer has two classes of scale to clean out instead of one. Then again, if the heater has been sold by an ignorant salesman it may be installed in the plant, the feed water of which contains no carbonates, and all sulphates. In that case the heater is useless as a purifer because the scale will continue to form in the boiler as usual.

WATER SOFTENING SYSTEMS

In regards to water softening systems, care must be taken to see that these are installed only after careful study of the chemical conditions involved. We frequently come in contact with purifying plants where scale continues to form in the boilers. In such case it develops on investigation that the chemicals used in the purifer or softener are not the right re-agents and fail to act upon the solids in the water, or possibly make them worse then before.

TREATMENT MAY BE UNNECESSARY

It is a mistake to imagine that all of the cases that are sent to us require chemical treatment. We occassionally meet with samples of feed water which are so constituted that it is far more economical to omit treatment. It is not infrequent to discover boilers where harmful compound was used where no chemicals

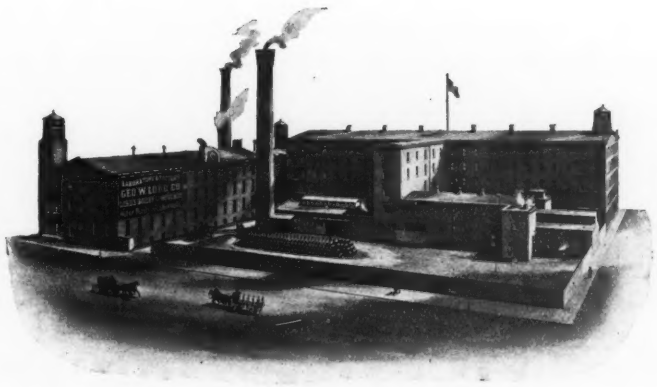
Lord's

were required whatever. In such cases, after a short treatment to overcome the damage done, we give instructions to keep all chemicals out of the boilers and no further trouble is experienced. It is a great surprise to our correspondents when they learn from us that no chemicals are required in their case and that consequently we have no quotations to make. They forget of course that there are two sides to this business. We are in the market, it is true, to supply water purifying chemicals, but by far the more important department at our plant is our laboratory.

OPINION IS FINAL

For many years Mr. Lord has patiently investigated and advised until to-day his opinion is practically final. Added to this the fact that all parts of the world send in problems for solution and it is apparent that Mr. Lord's life work has been a success, and that his services to Industrial Chemistry will in due season be valued as highly as they deserve.

GEO. W. LORD COMPANY



NEW LABORATORIES AND WORKS

2238-50 NORTH NINTH STREET

PHILADELPHIA, PA.

HAVE YOU SENT US A SAMPLE OF SCALE?

If so, You are Interested in This:

If you sent us the sample of scale you know that we sent you the small souvenir promised and a Certificate of Analysis of the scale. Then we wrote you giving information about our methods.

You are now ready for our next proposition This will interest you far more than our offer of a small present for the scale.

Cut out the coupon below and fill it up properly. Send it to us and we will mail you full particulars about our new offer.

This applies to every man who sent us a sample of scale since August 1st, 1905.

Geo. W. Lord Company

2238-50 North 9th Street

Philadelphia, Pa.

Geo. W. Lord Co.
2238-50 N. 9th St.
Philadelphia, Pa.

Gentlemen — Kindly send me, free of cost, your Special Proposition.

Name _____

Home Address _____

Certificate of Analysis No. _____

Firm's Name _____

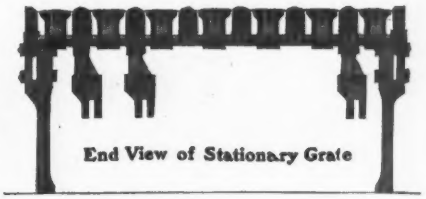
Firm's Address _____

City _____ State _____

September _____

The Practical Engineer

Reagan Grate Bar Co.


End View of Stationary Grate

"WE CAN DO WHAT REAGAN CAN"

You hear it everywhere, not because it is a truthful statement, but simply for the effect it might have on some unsuspecting buyer. The truth is "NO ONE CAN DO WHAT REAGAN CAN." We can prove that a Reagan Grate will evaporate 25 per cent. more water per boiler than any other grate or stoker working under similar conditions. Remember, we except nothing on which a fire is built.

OUR CHALLENGE;

We will equip a battery of boilers, no matter how large, with Reagan Grates; and, if they do not prove their superiority over any other grate or stoker, we will donate the grates to the firm in whose plant the test is made. Try to get a similar proposition from any other manufacturer of a grate or stoker and you'll not even hear him whisper "WE CAN DO WHAT REAGAN CAN."

Reagan's Reward

After testing 12 Reagan Grates over a year and their fulfilling all we claim under the terms and conditions guaranteed in our CONTRACT, the Boston Elevated Railway Co., sent us their order for EIGHT more LARGE REAGAN GRATES. This order comes to us unsolicited and is the best PROOF obtainable, as to the value of Reagan Gates. What say you?

We have also equipped the 10 power plants of the Boston & Northern Street Railway Co.

NOW, we want you to consider what it signifies, when such large users of Grates as the Boston & Northern Street Railway Co., and the Boston Elevated Railway Co., endorse and authorize the use of Reagan Grates, exclusively; after having used and experimented with all kinds and makes of grates and stokers.

If you are short of STEAM, don't you think it advisable to let us do for you what we are doing for the above Companies and hundreds of others throughout the World?

If interested, write for catalogue and copy of our contract.

Side View Stationary Grate

Reagan Grate Bar Company

205 N. Front Street
PHILADELPHIA, PA.

Acknowledged experts in the scientfic consumption of coal

The Peerless is Peerless

PEERLESS

Piston and Valve Rod Packing

If you have never used Peerless you have never thoroughly enjoyed the hum of an engine in perfect working order.

Get a box to-day and enjoy the "HUM."

12 to 18 months perfect service.

MANUFACTURED, PATENTED AND COPYRIGHTED EXCLUSIVELY BY

THE PEERLESS RUBBER MANUFACTURING CO.

16 WARREN STREET, NEW YORK

16-24 Woodward Avenue, Detroit, Mich.
Corner Common and Tchoupitoulas Streets, New Orleans, La.
210-214 N. Third Street, St. Louis, Mo.
1218 Farnam Street, Omaha, Neb.
16-18 S. Capitol Ave., Indianapolis, Ind.
202-210 South Water Street, Chicago, Ill.
634 Smithfield Street, Pittsburg, Pa.
1621-1639 17th Street, Denver, Colo.
220 South Fifth Street, Philadelphia, Pa.
17-25 Beale Street and 18-24 Main Street, San Francisco Cal.
Railroad Way and Occidental Avenue Seattle, Wash.
1221-1223 Union Avenue, Kansas City, Mo.
709-711 Austin Avenue, Waco, Texas
51-55 North College Street, Charlotte N. C.
Corner Ninth and Cary Streets Richmond. Va.